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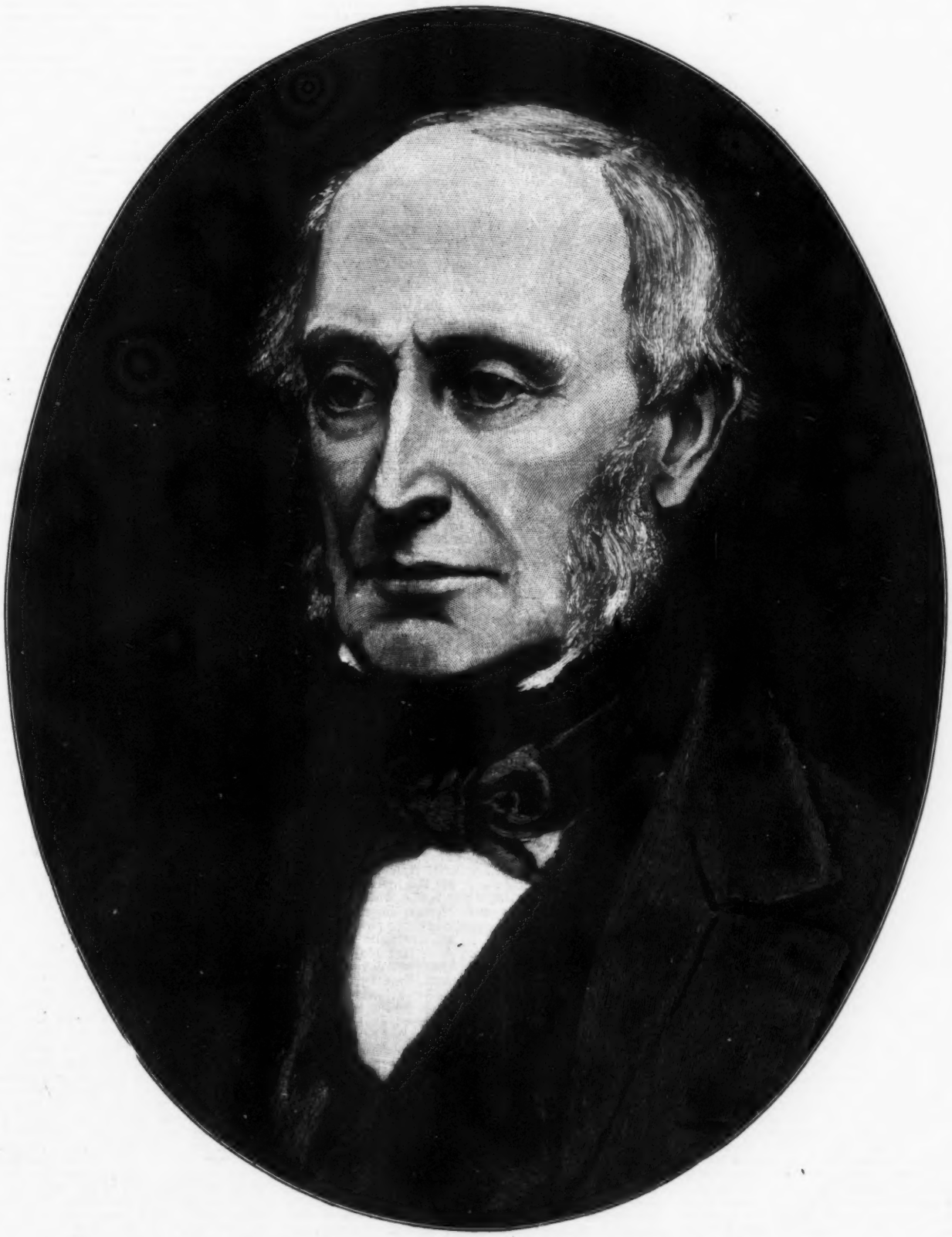


THE LATE LORD ARMSTRONG, INVENTOR OF THE ARMSTRONG GUN.

BORN NOVEMBER 26, 1810; DIED DECEMBER 27, 1900.

LORD ARMSTRONG.

WILLIAM GEORGE ARMSTRONG was born on November 26, 1810, and he had, therefore, lived to the great age of a month over ninety years. He was the son of Mr. W. Armstrong, a merchant of Newcastle-on-Tyne, his mother being the daughter of Mr. William Potter, of Walbottle Hall, Northumberland. In a manner almost unique, he combined in himself the characteristics of the true engineer and the organizer of great undertakings; a type which never fails to appear in the front rank. For so many years he filled a foremost position in the contemporary history of the country, that the chief incidents of his most successful career are fairly well known. It was often told how he was educated as a lawyer, and, indeed, commenced life as a solicitor in the firm of Donkin, Stable and Armstrong, later studying in the office of his brother-in-law, Mr. W. H. Watson, afterward Baron Watson, then a special pleader in the Temple. Fortunately for England, he soon found his true path in life. He commenced his engineering career as an amateur, making experiments in his leisure time. These distractions became so engrossing that the dry practice of the law soon grew distasteful, and he determined to abandon it as a profession, and cast in his lot with the mechanical pursuits which had for him so engrossing an interest. There then existed a small engineering works owned by Messrs. Donkin, Cruddas, Potter and Lambert, who conducted an unpretentious business on the Tyne at Elswick; a spot where, years after, Lord Armstrong told a meeting of naval architects that he used to fish for salmon in his youthful days. In 1847—the year the Institution of Mechanical Engineers was founded—Armstrong officially joined this firm, and his energetic presence soon wrought a change in the practice of the works. His experiments had been largely in the direction of the application of hydraulic power, and it was to the extension of machinery of this nature that the enthusiastic new partner devoted his energies. One of the most important of the early orders obtained was for the hydraulic cranes at the Trafalgar goods station at Newcastle. In 1850 the application of the loaded accumulator gave a great impetus to the work done by the firm, and the progress made in extending its field of operations was rapid.

Later on, the events of the Crimean War caused him to turn his attention to that branch of engineering construction in which he has won most fame, and with which his name will always be closely identified. Proceeding on his usual plan of associating experiment with inductive reasoning, he worked on the problem of improving ordnance until the year 1858, when he had brought his investigations to a practical issue. The old smooth-bore cast-iron or bronze cannon, with spherical projectile, loaded at the muzzle was not a weapon likely to commend itself to an originating engineer like Armstrong. The material used—cast iron—was by no means well suited to withstand the tensional stress and percussion shock due to the explosion of the charge; so that the gun had to be unduly heavy even for the comparatively low pressures then set up by the burning of the powder. All this is commonplace to us now; but to appreciate the originality of the daring young engineer of that day, who had never been professionally connected with the design of ordnance, we must remember that cast-iron cannon and round cannon balls had been so firmly established by long use, that the practice was hardly questioned by the naval and military experts of the day—a class which has always been averse to change. It is worthy of note, however, that the two great changes in the construction of ordnance which Armstrong did so much to bring about are of quite respectable antiquity in their inception. There is, we believe, still at Woolwich an ancient piece bearing the date 1547, which is rifled with six fine grooves having a twist of one turn in 28 inches; although, as is pointed out by Lloyd and Hadcock, in their admirable work, "Artillery: Its Progress and Present Position," it is very improbable that there was any idea of using elongated projectiles at so early a date; and thus the advantage of giving the shot a gyroscopic action was very problematical. This interesting relic of three and a half centuries ago is further remarkable as being a breechloader, and, indeed, the opinion was freely expressed, and afterward acted upon, by practical artillerists that breechloading cannon could not practically be used with advantage. There is, however, an earlier example of a breechloading cannon than that referred to, for Lloyd and Hadcock give an illustration of a Spanish breechloading gun of 1370; while there is another in the Tower, picked up on the Goodwin Sands.

To return, however, to the renaissance of these inventions at the time Armstrong commenced his experiments: the heaviest regulation smooth-bore weighed no more than 95 hundredweight, and it was deemed impracticable to exceed that limit in a ship. The heaviest cannon ball was 9 pounds, and the biggest charge was 16 pounds of powder. Lord Armstrong lived to see guns made on his principle of 110 tons weight, loaded with a projectile of 2,000 pounds, and a charge of 960 pounds.

The way in which the enormous stresses set up by burning these mammoth powder charges have been met is well known now. Prof. Barlow, in writing on the action of hydraulic pressure in cylinders, had shown that the strength of a cast-iron cylinder was far from being proportionate to its thickness. The reasons being, that an internal layer of the metal might—owing to its shorter circumferential length—be stretched to the breaking point before the external layer might have nearly reached the limit of its resistance. He had also pointed out that "in order to obtain the greatest resistance to a bursting force in a cylinder, the external layer of the material must be in a state of initial tension, which should diminish in each succeeding inward layer, until a neutral point is reached; beyond which a state of compression must prevail, gradually increasing to a maximum at the interior surface." In America an ingenious effort was made to turn this principle to use by cooling the bore of a cast-iron gun with water on taking it from the mould. The outer layers being thus kept plastic longer than the inner part, the former would shrink round the latter in the same way as a hoop shrunk on.

The way in which Sir William Armstrong applied the principles enunciated by Prof. Barlow to gun construction was by the now well-known plan of shrinking hoops or rings on to an inner barrel, or A tube, as it is called. The latter extends the whole length of the piece, and is formed of steel, the rifling being cut on the interior. Prof. Barlow worked out his theory on mathematical principles, and much mathematics have been expended on finding the exact tension which should be set up in the hoops. As a matter of practice, it would be very difficult to translate these scientific deductions into practical work; but fortunately that is not of great consequence, and a little extra pressure above that theoretically desirable is not a disadvantage.

Another method of obtaining the same end, and one which is in some respects more desirable than shrinking on hoops, is that of winding wire at required tension round the A tube forming the bore. This idea was suggested by Capt. Blakely in February, 1855, and a few months later a patent was taken out by Longridge. The late Mr. Brunel also independently conceived the same idea some time after, and commissioned Sir W. Armstrong to make a gun for him on this principle. When it was found, however, that there were patents on the subject, the project was abandoned; and it was not until after many years, and after the patent had expired, that Armstrong put the idea into practical shape by making a 6-inch breechloading gun. The long and hopeless fight of the late Mr. Longridge to get his gun tried will be within the memory of most of our readers; and even here we cannot help expressing regret that what is now proved to be so meritorious an invention, should have brought little but sorrow and trouble to its originator for so long a period of time. There is a moral in the business, as there is in all failures of praiseworthy mechanical inventions. It is, that to push to fruition an idea involving great outlay, one must be in a position to spend money oneself, or have the business qualities to induce other people to spend it for one; and this applies with tenfold force when the success of the invention involves the approbation and co-operation of a public department, especially a military department.

The advances made in the carriages and mountings of ordnance have been no less remarkable than those appertaining to the gun itself. When Armstrong first turned his attention to the improvement of cannon, the naval gun-carriage was a very primitive structure, and, indeed, almost remained so until as late as 1860. It was made almost entirely of wood, and was mounted on small wheels for running in and out. The wheels had very large axles, as dependence was placed on their friction to check recoil. Sometimes the rear wheels were left out, so that the back part would slide on chocks of wood. There was a breeching of stout rope to take up the last of the recoil. Handspikes were used to train the gun, the whole apparatus, gun and carriage, being levered bodily in the desired direction. The required elevation was obtained by wedges pushed between the carriage and the gun, although an elevating screw was substituted later for the purpose of greater accuracy.

With so rude an outfit it is easy to understand why naval actions were always fought at close quarters, often yard-arm to yard-arm; for to play long bowls, with cannon balls fired from smooth-bore guns, trained by handspikes and elevated by wedges, would afford a very poor chance of doing an enemy an injury.

About 1864, iron was substituted for wood in the construction of gun carriages. We do not know exactly what part Armstrong played in the change, but it will be easily understood that once the stronger and more plastic materials were introduced, the rate of progress would be rapid in the hands of an engineer of such ability. Slides and traversing platforms for the carriage to run on were the first notable improvements; but still the appliances for training and elevation were insufficient for guns of the size it was desired to introduce, with their ever-growing charges and great weight of projectile. The increased speed of ships also had to be taken into consideration, for if a gun were not easily trained the enemy would be out of effective range before the round could be fired. The newer guns were, therefore, given a training of 120 degrees in place of 90 degrees as before.

Something more was also needed for checking motion than the old methods, and a mechanical brake was devised. It consisted of a number of short iron plates on the carriage, and these interlaced with long plates or bars on the slide, in such a manner that both could be clamped together by the vise action of a piece called the compressor jaws. A frictional resistance was thus produced when the carriage was set in motion. This was the well-known compressor brake, which was used for some time with success. It was, however, not effective enough for the heavier and more powerful guns then fast coming into use, so the hydraulic buffer was introduced. This, however, gave trouble with the valves, and ultimately the well-known Vavasseur system was devised and introduced about twenty years ago, its inventor eventually joining the Elswick firm.

In 1858 Sir William Armstrong joined the Institution of Mechanical Engineers, he being at once elected to the office of Vice-President, while he became President in 1861. The address the new President delivered was a polished piece of literature, as was all that proceeded from his pen. He devoted himself largely to historical retrospect, but in speaking upon his own more especial subject, he dealt with matters then more of the immediate present. He referred to the advances made by the French, "always forward in everything appertaining to war," in the rifling of ordnance, and the application of defensive armor to ships. Later on, he bore tribute to the success of another foreign nation in the art of war. "It is seldom," he said, "that the enterprise of English manufacturers is exceeded by that of foreigners, but in the production of steel forgings of large dimensions, Krupp, of Essen, has taken the lead of all steelmakers in this country." This reproach, uttered forty years ago, is hardly removed to-day, in spite of the sanguine prophecy with which the address was continued.

As will be remembered by many of our readers, Sir William Armstrong was a firm believer in those early days of the superiority of wrought-iron over steel for the manufacture of cannon, being opposed in this view by both Krupp and Whitworth. Whatever may have been the outcome of the now classic controversy that was waged in the sixties, in forming an estimate upon the merits of the dispute, we must remember that the subsequent improvements in the manufacture of steel have put the question on a very different platform. It may be that the superior steel made by Krupp accounted for the divergence of views between the great gun-making authorities; but, in any case, the fight is fought out now. Sir William Armstrong then recognized that steel had much greater tensile strength than wrought iron, but held that it was less adapted to resist concussive strain. This conclusion he supported by the fact that "armor plates made of steel have proved on every occasion of their trial greatly inferior to plates of wrought iron." This was said in 1869, when he was again President of the Institution of Mechanical Engineers. Time has since wrought a vast change.

Sir William Armstrong himself worked at the improvement of armor-plating. Some years before delivering (in 1869) the address to which reference has been last made he tried the effect of toughening steel in large masses by immersion, when heated, in oil. He hoped that in this way the objectionable brittleness of the metal would be got over, and that by the process he would be able to produce steel armor-plates of extraordinary resisting power. He accordingly made an armor-plate of steel, which was tempered in an oil bath. Its quality was tried by test-pieces cut off after tempering, and proved by tension and bending. The result showed a very high tensile strength, combined with so much toughness that it was superior in this respect to wrought iron: a great triumph for those days. Sir William was naturally sanguine of success, and the plate was sent to Portsmouth to be tested, but two shots from a 68-pounder gun sufficed to break it in various directions, and, as its maker said, "it was justly pronounced a failure."

Lord Armstrong from the first was a strong believer in the gun as against armor, and his partisanship never wavered all through the celebrated "duel" which lasted so many years. Whatever thickness of armor might be worked into a ship's structure, he was confident a gun could ultimately be made that would put a projectile through it. On the basis of this assumption, he was greatly in favor of small unarmored vessels heavily armed, of which vessels the "Staunch" class were notable examples. The origin of these now obsolete little craft appears to have been the Elswick proving barge, which was used as a mere floating gun-carriage for the trial of 12-ton guns at sea, even when the swell was considerable. Mr. Rendel, one of the Armstrong partners, evolved from this the "Staunch" design. The barge was 60 tons displacement, and had no propelling machinery; but the "Staunch" was somewhat larger, having twin screws and steam power for working her 12-ton guns. There was no armor, as such an addition would have necessitated a bigger hull, offering more target and a more costly construction. Speaking in 1869, Sir William said that "guns of the largest size now made, or ever likely to be made, may be mounted on similar vessels to the 'Staunch' without increasing their tonnage more than a proportionate degree." It is evident he then had but little conception to what his own work in gun design would lead; and, indeed, the "Staunch" type of vessel was based on a misconception of the true work required of the navy for the protection of our national interests. Lord St. Vincent's teaching had been forgotten at that time, but happily has been remembered since.

It was perhaps, natural that one not a seaman, who had done so much to revolutionize the science and practice of marine artillery, should be apt to look on the war vessel largely as a floating gun-carriage. But to take that view is to mistake what is the true function of the British navy, the duty of which is to keep the sea, and take our frontier to the enemy's coast line. To perform such a task involves many more things in the whole design than a preponderance of gun power, important as that element is. It is also natural that the head of the great Elswick firm should be impressed—perhaps unduly impressed—by the triumphs of naval architecture produced by the two great constructors who have directed the fortunes of the Elswick shipyard. The cruisers designed by Sir William White and Mr. Philip Watts are so eminently fitted to the work for which they are intended, that it may well seem they would be paramount in other positions.

In 1862, Sir William Armstrong said, in speaking of the value of armor, "It appears to me to be a question of plated ships or none at all, so far as the line-of-battle ships are concerned." Twenty years later, in his address as President of the Institution of Civil Engineers, he said, "Even if the victory of armor over guns should be ever established, it will still be a question whether it would be worth while to incur the enormous expense incident to the use of armor for the one advantage of resisting projectiles, seeing that however invulnerable by shot a ship may be rendered, it must remain equally assailable by rams and torpedoes." That was in 1882, but during the eighteen years that have since elapsed closer study and some experience have robbed rams and torpedoes of the terrors that are inseparable from the unknown.

Following up Sir William Armstrong's views to a later date, we find him putting forward opinions less open to criticism. In 1889, by which time he had become Lord Armstrong, he took part, at the Newcastle meeting of the Institution of Naval Architects, in the discussion on the paper contributed by Mr. W. H. White, the Director of Naval Construction (now Sir William White). It will be remembered that Sir Edward Reed had criticised the distribution of armor in some of the designs of Her Majesty's ships as not affording sufficient protection. "We may come to this conclusion," Lord Armstrong said, "that if we render a ship absolutely safe from being sunk by modern artillery, we shall simply eliminate its power of sinking anything else." That is an opinion that will hardly be controverted, but it is one needful to impress. It is too often the case that a design is condemned because it possesses one element of weakness, the critic being oblivious to may defective qualities that would be admitted in curing the one fault; in short, battles cannot be fought on sea or land without running risks. Later

on, in the same discussion, Lord Armstrong entered on more debatable ground in condemning battleships of large size. "Upon the whole," he said, "and upon what I have learned on this occasion, only tends to increase the disfavor with which I look on the armored class of battleships as a whole. . . . We incur so enormous a cost in this construction, that we cannot have a numerous navy if we devote our resources chiefly to the production of such ships. We require, for the protection of our commerce and for general services, that our navy should be extremely numerous; and the only possible means of obtaining a navy of sufficient number for that purpose, is to restrict our expenditure upon ships of this class, and increase our expenditure upon ships of the cruiser class."

It would be out of place here to enter into a discussion on such a subject as that raised by these quotations; but we may state it is extremely probable that by far the greater number of naval officers would be more likely to agree with Sir William Armstrong of 1862, when he said, "plated ships or none at all," than with Lord Armstrong of twenty-seven years later, when he advocated cruisers in place of battleships. No doubt at that date—as indeed at all dates, since the want of frigates almost broke Nelson's heart—we were lamentably short of cruisers, and without its satellites the battleship loses half its efficiency. Still, the ship strong in offense and strong to resist shot and shell is now, as it always has been, the true man-of-war, which gives the power of the sea, and makes invasion of England, and of her ocean possessions, impossible. That was so even in the days of "masts and sails and wooden walls," when ships of the line were those constructed to stand battering, while the swifter frigates of lighter scantling were liable to be sunk by a single broadside.

In 1858, the ordnance department was added to the Elswick Works, and some time after this Mr. Armstrong was appointed engineer of rifled ordnance to the government, and from 1858 to 1863 the ordnance department at Elswick was practically carried on as a government establishment. The arrangement was not likely to be one either permanent or satisfactory, and it was a happy day for every one concerned when it came to an end, although doubtless it served its turn. The freedom of the works led to a large number of orders being taken at Elswick for foreign governments, thus bringing trade to the country, and enlarging an establishment in the north which would be an immense source of strength in case of war.

The various controversies that raged for a time round the name of Armstrong, in regard to ordnance, have left only faint echoes in the present day. Like all innovators, he made enemies and was virulently attacked. Looking back on some of the correspondence of "experts" of the day, one finds it strangely suggestive of the controversy over water-tube boilers that is still with us. There were those who anathematized built-up guns, rifling, breechloaders, elongated projectiles, and all other dangerous, useless, and newfangled devices; and more especially their creators. They would have nothing but good old-fashioned cast-iron guns and honest round cannon balls, which had been tried for years and never found wanting!

Naturally, in introducing the new ordnance, troubles arose, and accidents occurred which gave color to these objections. The breech-action was the chief difficulty, and, as is well known, the dangers real and imaginary attending its use were considered so serious, that breech-loading guns were excluded from the service for a far longer period than was safe. Even now several of the ships in the Navy List are more or less ineffective, owing to the reaction due to the defects of the original breech mechanism. Sir W. G. Armstrong invented both the screw and wedge methods of closing the breech. The original screw system was first considered inferior to the wedge system, but the latter was ultimately found to be defective. Whitworth brought out a breech-block worked by a rack and pinion, but this also was found to have serious drawbacks. It was the French invention of the interrupted thread, and the improved methods of obturation, that made breech-loading the success it has since become; but, long after the breech-loading principle had proved its superiority, our ordnance officials and authorities adhered to muzzle-loading, with what might have been fatal pertinacity had we become involved in a serious naval war.

We must, however, leave the question of artillery, much as there is that might be said about Armstrong's inventions and his influence on the progress of ordnance construction. In 1899 we published a long illustrated description of the Elswick Works and their productions, which those of our readers who desire further information on the subject might refer to with advantage.*

Lord Armstrong was an enthusiastic worker in the more recondite branches of physical research, but much of his investigation in this field is unknown beyond a very narrow circle. One of the most interesting of his experiments, although begun more than fifty years ago, has only been completed and made known to the public within the last two or three years. In a beautifully got-up work, published by Smith, Elder & Co. in 1897, an account is given of a very beautiful electrical phenomenon which he illustrated by means of experiment. The results are so interesting, and the matter generally exhibits the subject of our memoir in so different a field of research to those we have dwelt upon, that we give a rather full extract from the work, even at the risk of carrying our notice to quite unusual length, and although the experiment is now well known to physicists.

"More than fifty years ago, when using my large hydro-electric machine before it went to the Polytechnic Institute, I hit upon a remarkable experiment. Taking two glasses filled to the brim with chemically pure water, I connected them by a cotton thread coiled up in one glass, and having its shorter end dipped in the other. The two glasses were joined up to a machine, the one containing the coil of thread by a negative wire, and the other by a positive connection. On putting the machine into full action, the coiled thread was rapidly drawn out of the negative vessel and deposited in the positive one, leaving for a few moments a rope of water about 0.3 inch in length suspended between the lips of the two glasses. The experiment was made with the machine in the open air, and its highest power was required for producing the effect.

"The experiment presents strong evidence of two currents flowing simultaneously in opposite directions, the negative inside the positive."

Later on, the author stated that, at an advanced age, he made the experiments afresh, and from movement in water passed to that of air. The result of this research was a monograph, illustrated by photography, of the highest interest. In this work the water-cotton experiment is explained as follows: "The duality of electricity, apart from quantitative distinction, has been shown to consist largely, if not wholly, in difference of direction, the motion in one case being outward and forward, and in the other inward and backward, as in the smoke ring." A point of interest also is, that examples were shown in the experiments of the remarkable correspondence between some electric figures and living organized forms. The conclusion Lord Armstrong arrived at—the salient impression it left on his mind—was "that electricity is identical with the inherent motion of molecules." Faraday once said that there is probably as much electricity in a single drop of water as would produce a thunderstorm, if free; and Lord Armstrong saw no reason to dispute it, provided we acknowledge all states and conditions of electricity as modes of motion. "There can," he says, "be no such thing as motionless electricity. The term 'statical' only implies bondage and absence of current." Lord Kevlin has said: "It is scarcely possible to help anticipating the arrival of a complete theory of matter, in which all its properties will be seen to be merely attributes of motion." Lord Armstrong well adds to this: "But motion of what?" Prof. Stroud followed up the investigations for Lord Armstrong, and the results were published in 1892, Lord Armstrong writing a preface.

Lord Armstrong held strong opinions on the danger which threatened the country through the exhaustion of our coal fields; and urged a more careful husbanding of our resources through greater economy in burning, and by taking advantage of other sources of power. His investigation into the generation of electricity by means of an escaping jet of steam—mentioned in the quotation given above—is well known, and on this principle he constructed his hydro-electric machine, which consisted of an insulated boiler from which steam at high pressure was allowed to escape through nozzles. The apparatus was tested by Faraday, who took much interest in the subject. Lord Armstrong also studied the question of utilizing the heat of the sun as a source of power, and calculated that the heat given off by the sun acting on one acre of ground in the tropics would be equal to 4,000 horse-power exerted for nine hours a day.

We have spoken of the late Lord Armstrong as an inventor and as a scientific worker and experimentalist, but there was a side to his character upon which we have not touched, and can do so but briefly here, although it contributed as much, if not more, to his success in life as all his rich endowment of engineering genius. He had a most engaging personality, which sprung from natural amiability of character. His power to attract to him and devote to his interests all with whom he came in contact or who were engaged in his service was remarkable. He had, moreover, unerring judgment in selecting those who were to collaborate in building up the immense business of which he was the chief; and, above all, he had the good common sense to allow those who were worthy of taking leading positions to be remunerated in accordance with their deserts. It is, perhaps, to the wise liberality he displayed in the latter respect that the phenomenal success of the great Elswick firm is, above all else, due. That he was a hard worker need, perhaps, hardly be mentioned; and he had also that great faculty of mental concentration, without which so much hard work runs to waste. His one defect as an engineer was that he had little gift of draughtsmanship; but his rich natural endowments in all other directions, together with his amiability, tact, and strong commonsense, rendered this somewhat serious defect for most engineers of small ultimate consequence, for he always obtained most ready service and hearty co-operation from all who worked under him. For our article we are indebted to Engineering.

The portrait of Lord Armstrong which accompanies this memoir is from The Illustrated London News.

* See Engineering, vol. xlviii., pages, 451, 480, 510, 550, 579, 598, 621, and 648.

CONTEMPORARY ELECTRICAL SCIENCE.*

GAS BATTERIES.—Chemical studies have enabled F. Haber to put forward the proposition that the oxidation potential of hydrogen peroxide, together with its reduction potential, represents the oxygen potential. This result, which may be deduced from thermodynamical considerations, implies that for fixed values of the hydrogen concentration and the oxygen concentration there is only one stable value for the hydrogen peroxide. That value obtains at the oxygen electrode, and remains constant as long as that electrode operates in a reversible manner. But the concentration of the hydrogen peroxide does not affect the dynamics of processes in which the maximum work is yielded, and which can be reduced to the work of a battery of the form

Metal | metallic ions | hydroxyl ions | oxygen electrode.

When the processes are rapid, however, certain metastable conditions may occur, and it is to such conditions that the author attributes the phenomena observed at a platinized platinum electrode dipping into hydrogen peroxide solution, as well as the catalysis of hydrogen peroxide by finely divided platinum.—F. Haber, Phys. Zeitschr., December 1, 1900.

IONIC SHOOTING.—In many cases the flow of electric current in gases is a process strictly analogous to the flow of electric current in liquids. It consists of a migration of ions in two opposite directions, the direction varying in accordance with the force, and the velocity being proportional to that force. But in the case of gases, with their greater free path, it is possible that an ion retains its velocity after arriving at a point where the electric force is feeble. This process has been termed "ionic shooting" by J. Stark, and he now mathematically investigates several of its aspects. When the ionic shooting is combined with a diminution of the electric force in the direction in which the ions "shoot," as well as a diminution of their velocity by collision, internal charges are produced. Thus, if a vacuum tube is constricted at a point situated within the positive-light column, the electric force, being greater at the constriction than in the wider spaces on either side, produces a positive charge on the cathode side and a negative charge on the anode side of the constriction. Ionic shooting tends to the preservation and exaggeration of any existing minima and maxima of electric force. This is exemplified in the stratified discharge. If the path of the discharge is curved, ionic shooting brings about a certain centrifugal force which throws the ions out of their natural path.—J. Stark, Phys. Zeitschr., December 1, 1900.

USE OF A POLARIZING CELL IN THE TELEGRAPHONE.—It has already been announced that the introduction of a polarizing cell in the circuit of the recording electromagnet considerably increases the sharpness and clearness with which the sound is rendered. The observation is now explained by E. Ruhmer. The preliminary magnetization probably never exceeds 12,000 units, and after the wire leaves the neighborhood of the electro-magnet its magnetic intensity probably falls to about 8,000 units. When the wire is used for recording, its remanent magnetism will then induce pretty high magnetizations in the core of the recording electromagnet, with a maximum of some 8,000 units. Now this value, when looked up on the curve of magnetization, is seen to correspond to a low permeability, where comparatively large variations of the magneto-motive force only produce small variations of the magnetic flux, and therefore, also small amplitudes of the magnetic waves to be impressed upon the wire. But for loud records it is important that the variations of the magneto-motive force should take place on a steep portion of the magnetization curve. That condition is fulfilled by introducing a cell in the circuit which shall just compensate the magnetism induced by the wire in the core of the electromagnet. In Poulsen's case the E.M.F. required is only 1 volt.—E. Ruhmer, Phys. Zeitschr., Dec mber 1, 1900.

SEPARATION OF WIRELESS MESSAGES.—P. Jégou has devised a differential apparatus which, while not preserving the secrecy of wireless messages, enables the sender to communicate at will with one or another of two stations situated at different distances. The principle adopted is that already proposed of employing mast-wires of different ranges. Four such mast-wires are employed, two at the sending station and two at the receiving station. Their heights are so arranged that one of them covers, say, a range of five miles, while the other does not. The circuits of the coherers attached to the two mast-wires are so arranged that their simultaneous action produces no effect upon the galvanometer. But at a distance of five miles the galvanometer will respond to a message from the sending station addressed to both coherers, as only one of them is brought into action. At half that distance, when both coherers are within range, no effect is produced on the galvanometer. Thus, at all events, something of the nature of separation by distance is obtained, though it is open to the obvious criticism that complete neutralization of the two effects is only produced at one definite value of the distance. It would be better if the message itself were limited to this value instead of the absence of the message.—P. Jégou, Comptes Rendus, November 26, 1900.

MAGNETIZED CHRONOMETERS.—A. Cornu has turned to good account an accident which befell a chronometer when it was brought near a large dynamo. He reasoned that if it could be kept going for 24 hours it would keep going indefinitely if wound up only once daily, as all the moving parts would be in the same relative positions. Moreover, many of the actions, like the accelerations and retardations of the balance-wheel, would neutralize each other, and there would be no magnetic adhesion, as steel contacts are avoided in the construction of chronometers. In studying the behavior of this particular chronometer he found that it was considerably influenced by the earth's magnetic force. There was, in fact, a definite acceleration or retardation for each azimuth, the equations expressing this effect being similar to those representing the action of gravitation upon an imperfectly balanced wheel. The practical importance of these researches lies in their bearing upon ships' chronometers. The magnetism of their balance-wheels should be carefully determined, as well as the corrections necessary for various magnetic azimuths. The amplitude of the oscillation should be made as great as 440 deg., as pointed out by Phillips. Unfortunately, that is difficult of attainment.—A. Cornu, Comptes Rendus, November 26, 1900.

DEFENSE OF THE CADMIUM CELL.—W. Jaeger replies to the criticisms of the Weston cadmium cell put forward by Barnes and by Cohen. That the E.M.F. of the cadmium cell shows certain irregularities at 0 deg. C. was already found by Wachsmuth and the author in 1896, and at that time they indicated 5 deg. C. and 25 deg. C. as the limits within which the new standard cell could safely be used. Similar irregularities are known to occur in the Clark cell, due to the transition point occurring at 39 deg. C., below which the zinc sulphate may assume two different states, the normal curve being broken with respect to the portion above 39 deg. C. Such a behavior cannot be traced in cadmium sulphate. The metastability of the Weston cell must therefore be explained on some other ground, and this both the author and his critics now agree to find in the behavior of the cadmium amalgam, which experiences irregular changes of structure at low tem-

* Compiled by E. E. Fournier d'Albe in The Electrician.

peratures. The concentration of the cadmium amalgam was originally put at 14.3 per cent. It is now admitted that elements with that amalgam should not be used below a temperature of 10 deg. C. The cells brought out by the European Weston Electrical Instrument Company contain an amalgam of only 12.5 per cent, and they show no metastability even at 0 deg. C. —W. Jaeger, Zeitschr. Instrum., November, 1900.

[Concluded from SUPPLEMENT, No. 1309, page 20985.]

A NEW PAGE-PRINTING TELEGRAPH.

By WILLIAM B. VANSIZE.*

CONSTRAINED VIBRATION OF THE REED.

To secure this result there is placed at or near the free end and upon the opposite sides of the reed, resilient stops, shown at 12 and 13. These springs receive the reed on each side with a cushioning effect and impart an initial return movement. In explanation of this result it is to be recalled that the rate of vibration of a reed varies with its length, mass, and the distribution of such mass; increase of current in the motor magnet circuit increases the amplitude of vibration without varying the speed beyond the slight electro-magnetic damping effect already described. The energy imparted to the reed by the motor magnet is dissipated by the air resistance and molecular friction in the reed; an increase in the propelling energy brings a corresponding increase in the dissipation noted. Therefore, while the amplitude of vibration is widened, the speed is not increased. If fixed limiting stops be provided, to limit the amplitude of vibration, the energy of the reed cannot then be dissipated in the manner first described to the same extent, and there results an increase in the rate of vibration, while a portion of the energy imparted to the reed is dissipated in heat generated at the point of impact. To avoid this loss and further increase the rate of vibration, the energy which would otherwise be lost at a rigid contact is stored in the resilient devices, 12 and 13, already referred to, to cushion the impact of the reed, and impart an initial return movement. By this expedient, the movement of the reed is rendered smooth and uniform; it is freed from the interference due to the impact with a rigid stop, which acts to jar and disturb the normal rate of vibration, and its rate may be varied by varying the current impulses.

In further explanation of this device we may recall the fact that, within the limits of elasticity, a helical spring varies in length in arithmetical ratio with the force extending it; that is to say, if a helical spring extends one inch with a weight of one pound, it will extend two inches with the weight of two pounds, and so on. Within restricted limits the same rule holds good with simple flat springs of uniform thickness, like those commonly employed for electrical contact purposes. It has been found by experiment that springs of this kind, whether arranged for tension or for compression, do not vary the rate of vibration of the motor-driven reed to any appreciable extent in response to variations of current in the motor magnet circuit; but if resilient stops are constructed and arranged, like 12 and 13, to rapidly compound their resistance to the impact of the reed, they are practically operative for the purpose of varying the rate of vibration in response to variation in current.

CURVES OF VIBRATION OF REED.

I have here a diagram (Fig. 2) showing the action of a reed when free to vibrate without limiting stops, as compared with the action of the same reed operating under the constraint imparted by the tapering springs, called resilient limiting stops. The figures were obtained by varying the amount of current flowing through the reed magnet coils and then measuring the amount of tape fed through the perforator under control of the reed. The tape is fed forward one step for each vibration of the reed, and its extent therefore gives an exact record of the rate of vibration per minute. The receiving vibrator and other instruments were set to transmit and record at the rate of 112 words per minute, and the current in the reed magnet was then varied with the following result:

Current in Milliamperes.	Tape fed per minute. ft.	in.
350	24	0
325	23	4 2-3
300	23	0
275	22	6¾
250	22	1¾
225	21	8½
200	21	4
175	20	11
150	20	6
125	20	3
100	20	1-3

The action of the resilient limiting stops began at 100 milliamperes. The vibration with this amount of current was very slight. About 230 milliamperes were used for the 112 word rate.

The following table shows the effect of removing the resilient limiting stops, all other conditions being as before:

Current in Milliamperes.	Tape fed per minute. ft.	in.
350	19	6½
325	19	6½
300	19	7
275	19	6½
250	19	6¾
225	19	6½
200	19	6
175	19	7
150	19	8
125	19	9½
100	20	1-3

The reed did not vibrate reliably under 100 milliamperes, and even with that current it was feeble. The vibration did not become fairly strong until 125 milliamperes was reached. The figures and the curves indicate that the speed increases with decrease of current below 150 milliamperes. This was possibly due to the electro-magnetic damping effect of the iron armature vibrating in the magnetic field. Actual trial has shown that this effect is too feeble and unstable to be used for governing the rate of the reed by possible variation in the current. A more positive and reliable result was required, and it was supplied by the resilient limiting stops. It will also be seen by the diagram that above 150 milliamperes the rate of vibration of the reed is uniform irrespective of the amount of current when the reed is not constrained by the resilient limiting stops. This is indicated in the straight horizontal portion of the curve, *B*. Curve *A* shows the effect of the resilient limiting stops in causing an almost uniform acceleration of the speed of the reed in accordance with the increase of current. With respect to the curve, *A*, the variation in words per minute between extreme points is from 103 words with 100 milliamperes to 123 words with 350 milliamperes, and with respect to the curve, *B*, the variation in words per minute is from 103 words at 100 milliamperes to 101 words at 350 milliamperes, a perceptible decrease in the word rate, with an increase of 3½ times in the strength of current.

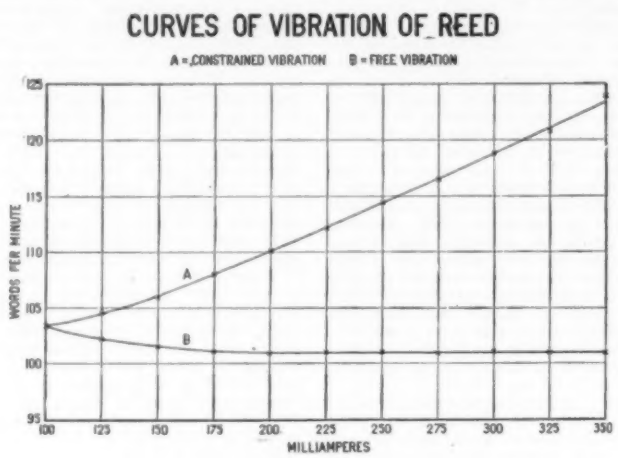


FIG. 2.

The forms of limiting stops experimented with and heretofore referred to are shown upon the diagram "Forms of Resilient Stops" (Fig. 3). Nos. 1 and 3 are practically ineffective for the purpose intended; No. 2 is susceptible of some beneficial use, while No. 4 is a practically successful arrangement, and the one to be preferred.

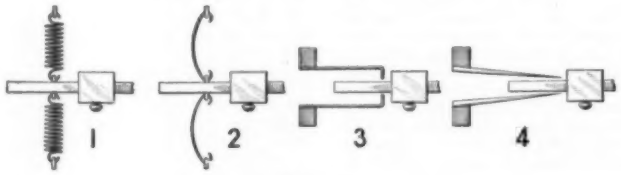


FIG. 3.

THE UNISON DIAGRAM.

I have here a "Unison Diagram" (Fig. 4) to illustrate the relative position of the current impulses in securing unison. There is shown a section of receiving-tape in which appears the word "Paris," the division between the letters being marked with a dotted line. Below the line of the tape is shown the corresponding conditions of current in the local and main line circuits; when in unison, and again when out of unison. In line 1 there is shown the current impulses in the punching magnet circuit effective to produce the perforations shown on the section of tape; line 2 shows the current impulses in the local spacing current; at line 3 is shown the main line impulses due to the operation of the automatic transmitter effective to produce the perforation in the tape represented; at 4 is shown the operation of the armature of the governing relay, the unshaded divisions representing the "armature transit time;" and the relative position of the armature transit with respect to the impulses in the main and local circuits; at line 5 is shown the impulses in the motor magnet circuit which operate to drive the reed; these impulses are shown as in unison with the main line and local circuit impulses. In line 6 is shown the same motor magnet circuit impulses out of step, or out of unison. The continuous operation of the unison device is best illustrated in the actual record taken upon a chemically-prepared paper tape with a pair of iron pens, one in the local circuit and one in the main circuit; the pens were arranged side by side; line 7 shows the record of impulses in the motor magnet circuit; line 8 shows the main line impulses, the action of the armature of the governing relay having been suppressed. In lines 9 and 10 the same means are employed to render graphic the impulses in the two circuits, and the operation of the transit of the armature bar, 26, of the governing relay is also apparent in clipping the local circuit impulses, and thus curbing their motive power effect on the reed. There is thus established a continuous "dynamic balance" between the tendency of the reed to accelerate its speed and the tendency of the main line signals to retard its speed. The shape of the punch for perforating the receiving tape is quite important. A large number of forms were tried. The diagram "Forms of Punch" (Fig. 5), shows some of the leading shapes. No. 5 is much the best.

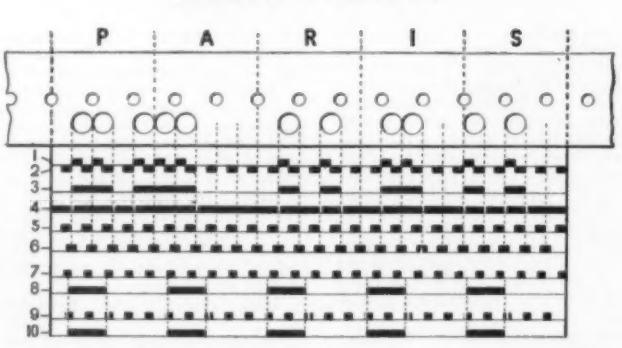


FIG. 4.

TELEGRAPHIC ALPHABETS.

In considering the merits of this arrangement of apparatus and in accounting for the want of commercial success of so many other arrangements, it may be said that printing telegraphs have not been generally employed for the following reasons, among others:

1. Delicacy and complexity.
2. Slowness of operation.
3. Limitation in the capacity of the operator.
4. The use of a tape for the received record.

Recently some arrangements of apparatus have been devised which overcome these difficulties by two radically different methods, i. e., automatic transmission and multiple transmission. The first uses the Wheatstone transmitter and perforated tape; the second employs direct manual transmission distributing the time for using the line between a number of operators. The slowness of operation has been due not only to the limitations of the operator, but also to the character and succession of the line impulses employed. In long distance working and with the growing use of underground and aerial cables, this is of extreme importance. The reliable material for high-speed signaling over long distances in printing telegraphy consists practically of five or six variations in the time interval; two variations in direction, and one

* A paper presented at the 150th meeting of the American Institute of Electrical Engineers, January 25, 1900.—From the Journal of the Society.

variation in strength, i. e., makes and breaks. Two very desirable conditions are that letters shall be of uniform length, and that either makes and breaks or reversals shall be used, but not combinations of the two. The Morse alphabet is ideal except for the great variation in the length of the characters.

The importance of an alphabet having letters of equal length has been generally acknowledged, and many designers have adopted the only practical arrangement, namely, thirty-two possible combinations of five positive and five negative elements taken five at a time. Such an alphabet was first suggested by Gauss and Weber, of Gottingen, in 1833. It was revived in 1874, when Baudot and others employed it for their multiplex printing telegraph systems. Baudot's arrangement, which may be taken as typical of this class of equal letter alphabets, is shown in the diagram called "Table of Alphabets" (Fig. 6). It has the disadvantage of using makes and breaks as well as reversals, necessitated by the use of equal units of current to form the various combinations for the letters.

THE MURRAY ALPHABET.

Murray by using multiple units of current and space (that is, by using several different time intervals instead of one only) avoids this disadvantage and has not found it necessary to use reversals, five different time intervals combined with makes and breaks giving all the combinations required. He has preserved the ideal simplicity of the Morse alphabet with the added advantage of securing letters of the same length. The Murray alphabet appears in the table; it will be seen that the uniform time for each letter is divided into five equal units or subdivisions, one or more of these five subdivisions being a current impulse, so that we get current impulses or spaces of one, two, three, four, or five units duration. Thirty-two possible combinations are obtained in this manner, and by using two of these letter signals as prefixes to the others, capitals, figures, and lower case letters, about eighty-seven characters, may be transmitted. Makes and breaks or reversals may be used, therefore, adapting the system for use in quadruplex transmission; a use not practicable with an alphabet employing both makes and breaks and reversals. The alphabet is, however, only available for machine telegraphy, as it is practically impossible to observe five different time intervals with sufficient accuracy in manual transmission. No space is required between letters in the Murray alphabet, whereas in the Morse a three unit space follows each letter. This is shown in the "Table of Alphabets." It will be seen upon examination that the maximum number of impulses required is three for the letter y, and the average number reckoned according to the frequency of the letters is 1.25 impulses as against 2.59 for International Morse. As compared with this 1.25 impulses per letter, a system employing the Baudot alphabet has to transmit not less than five, and this does not take into account the necessary correcting impulses to secure or maintain synchronism. Murray has the shortest alphabet possible to be constructed from reliable signaling material and by combining it with machine transmission the entire time of the line is used in the most advantageous manner possible.

COMPARISON OF ALPHABETS.

Referring to Fig. 7, "Comparison of Alphabets," it will be seen that the Murray word is shorter than the Morse in the ratio of 30 to 51, or 41.18 per cent. This theoretical diagram is borne out by a comparison made with an actual word such as PARIS. This comparison is made on lines 13 and 14. It will be observed that in this case the Murray alphabet is shorter than the Morse in the ratio of 30 to 49, or 38.78 per cent. Practically, the two alphabets are in the ratio of 3 to 5. Hence, using the same number and length of current impulses in each case, a speed of 100 words a minute with the Murray alphabet would not be more than about 60 words a minute in Morse. The saving in the Murray alphabet lies chiefly in the fact that there is no space between the letters. Indeed, signals in adjoining letters not unfrequently coalesce, as will be seen in the case of the letters P and A in the word PARIS, where one current impulse is actually shared by the two letters, and five letters are transmitted by seven impulses, whereas in the Morse representation of the same word no less than 14 impulses are required. Many combinations of letters like te, ta, ma, me, ou, are sent by one impulse, and the German name Latzke, consisting of six letters, requires only four current impulses for its transmission. This, however, is exceptional, the average being 1.25 impulses per letter. The Hughes printing telegraph employs only one impulse per letter, but it is extremely wasteful of the space between signals, so much so that, on the average, not more than three impulses per second are transmitted over a line which will easily convey thirty per second. The Murray alphabet, on the other hand, economizes spaces as well as signals to the utmost extent.

TESTS OF THE SYSTEM.

From time to time, as the system developed, careful tests were made of its capacity, both on loops of varying lengths and on circuits between cities. The speeds mentioned below were calculated on the basis of five letters to the word and a word-space equal to one letter. That is to say, the receiving tape fed through the perforator in one minute was measured to find the number of letters it contained, and this number was divided by six. In April and May, 1900, a series of tests were made between New York and Chicago. Working direct from Chicago to New York via Meadville without a repeater, a distance of 1,050 miles by the route of the wire, the best speed attained was 77 words a minute. Working with a repeater at Meadville, much better results were achieved, 102 words a minute being easily attained. The wire used was copper, 208 pounds and 4.5 ohms per mile. Duplex working was readily secured. Attempts were made to reach a speed of 114 words a minute. These were only partially successful, but the results gave promise of a speed of at least 120 words a minute in the future.

The most exhaustive tests of the system were made, from October 17 to November 3, 1900, between Boston and New York. Two hundred ordinary commercial messages were taken without selection from the files in the operating room of the Postal Telegraph Company in New York. They consisted of 160 business telegrams (including 18 in cipher) and 40 domestic and social. They averaged 10.9 words in the paid portion of each message. Following the usual practice of counting single figures as words, they averaged about the usual rate of 30 words per message; but counting figures as single letters, and counting all letters by measuring the transmitting tape and dividing by six, the average was about 26 words per message. These 200 messages were perforated in Wheatstone tape. A column press dispatch from The New York Herald, containing 5,988 letters and 1,261 words, or an average of 4.75 letters per word, was also prepared in Wheatstone tape. This press dispatch and the 200 commercial messages were transmitted from Boston to New York day after day at speeds varying from 60 to 96 words per minute. It was found that the apparatus worked with great accuracy, the whole 200 messages frequently coming through without error. At other times occasional errors occurred, owing to swinging wires and other familiar line troubles common to all telegraph systems. In addition to the 200 messages prepared beforehand in New York, a number of ordinary messages were perforated in Boston and transmitted to New York without difficulty, and almost without experience on the part of the Boston operators.

In regard to the number of messages transmitted per hour, in tests made when the apparatus was running at 61 words per minute, the 200 messages came through to New York in one hour 23 minutes. This is a speed of about 144 messages per hour, or more than three times the average rate of transmission by the Morse key, 40 messages per hour being regarded as a fair day's work for an average American operator. At the 96-word rate the messages came through at about 230 per hour. At the same rate the press dispatch, with the last part repeated, making in all 1,720 words, came through without an error in 16 minutes 42 seconds, or at the actual rate of about 103 words per minute, the words averaging only 4.75 letters each. A speed of 110 words per minute (115 actual words per minute) was tried, but at this rate not more than 200 or 300 consecutive words came through free from error. The inventor believes, however, that with increased skill and improved instruments, his system will ultimately reach a reliable speed of 120 words a minute. Working on a loop from New York to Albany and back, up one side of the Hudson River and down the other, speeds of 114 and even 118 standard words per minute have been successfully obtained. The length of the Postal Telegraph Company's lines from New York to Boston is about 290 miles, and the lines include from 20 to 30 miles of cable. Over this comparatively short line the system did not require any readjustment for weather, which varied during the tests from clear and cold to dense fog and rain all the way between the two cities. Duplex working was perfect.

It will be seen from the foregoing tests that this system, working at the 60-word rate, has a capacity of 140 messages per hour. Cutting this down to 120 messages per hour to allow for corrections and delays, and working duplex, there is an output of 240 messages per hour, or 50 per cent more than the Morse quadruplex can achieve. Working at the 96-word rate, the system has the capacity to transmit two and a half times as many telegrams as the quadruplex. No doubt these figures will be considerably reduced in commercial practice, but there is a wide margin for such reduction.

The tests have shown that, owing to the characteristic alphabet, distances of 1,000 miles are not an obstacle, and the inventor is sanguine enough to believe that it will be possible, though not at present commercially practicable, to work between New York and San Francisco, a distance of 3,000 miles, at a speed of at least 40 words a minute, or double the rate of manual transmission.

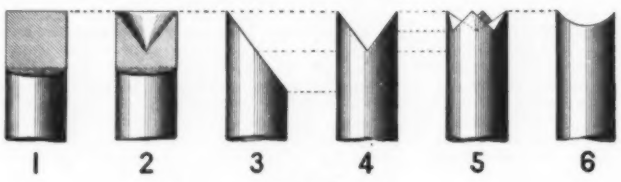


FIG. 5.

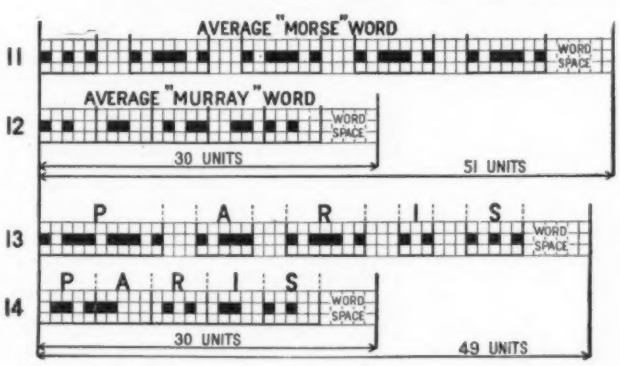


FIG. 7.

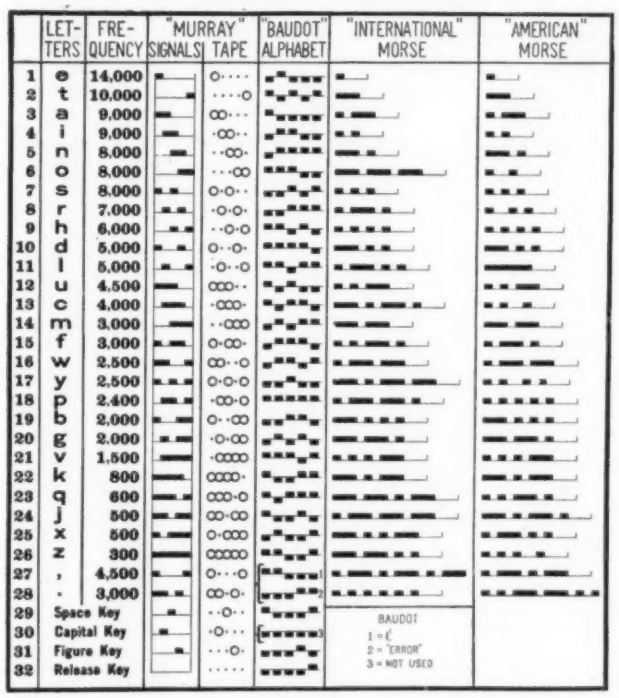


FIG. 6.

OILSKINS.

By ARTHUR LESLIE.

THE art of painting over textile fabrics with oily preparations to make them waterproof is probably nearly as old as textile manufacture itself, an industry of prehistoric, nay, geologic, origin. It is certainly more ancient than the craft of the artistic painter in oils, whose canvases are nothing more nor less than art-oilskins, and when out of their frames, have served the usual purpose of those things in protecting goods or the human body before now. The art of waterproofing has been extended beyond the domain of the oilskin by chemical processes, especially those in which alum or lead salts, or tannin, are used, as well as by the discovery of india-rubber and gutta-percha. These two have revolutionized the waterproofing industry in quite a special manner, and the oilskin manufacture, although it still exists and is in a fairly flourishing condition, has found its products to a very large extent replaced by rubber goods. The natural result has been that the processes used in the former industry have remained now unchanged for a good many years. They had already been brought to a very perfect state when the rubber-waterproofing business sprang up, so that improvements were even then difficult to hit upon in oilskin-making, and the check put upon the trade by india-rubber made people less willing to spend time and money in experimenting with a view to improving what many years had

already made it difficult to better. Hence the three cardinal defects of the oilskin: its weight, its stiffness, and the liability of its folds to stick together when it is wrapped up, or in the other extreme to crack, still remains. It may be that the trade in india-rubber waterproof goods being now in its turn seriously hampered by the cycle and the motor car, to say nothing of the private horse carriage and the hansom cab, the oilskin business will look up again and that the defects above rehearsed will be removed as far as is possible in the nature of things. The weight, of course, is inevitable. An oilskin must be heavy, comparatively, from the very essence of the process by which it is made, but there seems no reason why it should not in time be made much more pliable (an old-time oilskin coat could often stand up on end when empty) and free from the danger of cracking or being compacted into a solid block when it has been stored folded on a shelf.

Probably the best oilskins ever made are those prepared by combining Dr. Stenhouse's process (patented in 1864) with the ordinary method, which consists in the main of painting over the fabric with two or more coats of boiled linseed oil, allowing each coat to dry before the next is applied. This, with a few variations in detail, is the whole method of making oilskins. Dr. Stenhouse's waterproofing method is to impregnate the fabric with a mixture of hard paraffin and boiled oil in proportions varying according to circumstances from 95 per cent of paraffin and 5 of oil to 70 per cent of the former and 30 of the latter. The most usual percentages are 80 and 20. The mixture is made with the aid of heat, and is then cast into blocks for storage. It is applied to the cloth stretched on a hot plate by rubbing the fabric thoroughly all over with a block of the composition, which may be applied on one or both sides as may be wished. The saturation is then made complete, and excess of composition is removed by passing the cloth between hot rollers. When the cloth is quite cold the process is complete. The paraffin and the drying oil combine their waterproofing powers, and the paraffin prevents the oil from exerting any injurious action upon the material. Drying oil, partly on account of the metallic compounds in it, and partly on account of its absorbing oxygen from the atmosphere, has a decided slow weakening effect upon textile fibers. Dr. Stenhouse points out that the inflammability of oilskins may be much lessened by the use of the ordinary fireproofing salts, such as tungstate of soda or alum, either before or after the waterproofing process is carried out.

The following are some of the best recommended recipes for making oilskins:

1. Dissolve one ounce of yellow soap in a pint and a half of boiling water. Then stir in one quart of boiled oil. When cold, add one quarter of a pint of gold size.

2. Take fine twilled calico. Soak it in bullock's blood and dry it. Then give it two or three coats of boiled oil, mixed with a little litharge, or with an ounce of gold size to every pint of the oil.

3. Make ordinary paint ready to be applied thin with a strong solution of soap.

4. Make 96 pounds of ocher to a thin paste with boiled oil, and then add 16 pounds of ordinary black paint mixed ready for use. Apply the first coat of this with soap, the subsequent coats without soap.

5. Dissolve rosin in hot boiled oil till it begins to thicken.

6. Mix chalk or pipe clay in the finest powder, and in the purest state obtainable to a thin paste with boiled oil.

7. Melt together: boiled oil, one pint; beeswax and rosin, each two ounces.

8. Dissolve soft soap in hot water, and add solution of protosulphate of iron till no further precipitate is produced. Filter off, wash, and dry, the iron-soap, and make it into a thin paste with boiled oil.

All these compositions are painted on with an ordinary painter's brush. The fabric should be slightly stretched, both to avoid folds, and to facilitate the penetration of the waterproofing mixture. To aid the penetration still further, the mixture should be applied hot. It is of the greatest importance that the fabric should not be damp when the composition is applied to it. It is best to have it warm as well as the composition. If more than one coat is applied, which is practically always the case, three being the usual number, it is essential that the last coat should be perfectly dry before the next is applied. Neglect of this precaution is the chief cause of stickiness, which frequently results in serious damage to the oilskins when they have to be unfolded. In fact, it is advisable to avoid folding an oilskin when it can be avoided. They should be hung up when not in use, whenever practicable, and be allowed plenty of room. It goes without saying that no attempt should be made to sell or use the oilskin, whether garment or tarpaulin, until the final coat of composition is perfectly dry and set. It is unadvisable to use artificial heat in the drying at any stage in the manufacture.—Oils, Colours, and Drysalteries.

[Continued from SUPPLEMENT, No. 1309, page 20981.]

THE NINETEENTH CENTURY IN MEDICINE.*

SOME of the text-books of fifty years ago occasionally mentioned the use of electricity as a measure that might be resorted to in certain morbid conditions when everything else had failed. It was held in rather lower esteem than horseback exercise and sea-bathing. It was always referred to in the vaguest terms, and whenever it was used, which was very rarely, it was in the form either of the direct galvanic current or of that from the magneto-electric machine. Its haphazard employment doubtless did quite as much harm as good, for it was largely in the hands of the quacks, and those of them who resorted to it as their cure-all were forever flaunting before the public the dictum "Electricity is life." But before many years more had passed electricity, which from the physicist's point of view had already been made the subject of researches which were to culminate in its present multifarious usefulness to mankind, was investigated by the physiologist and then by the experimental therapeutist. As a result of these investigations, we employ it now in everyday practice, not only as a precious diagnostic test but also with well-founded expectations of its definite therapeutical action in a great number of morbid conditions. Nobody now prescribes its use under the bald appellation of "electricity"; we specify the form of apparatus to be employed, the galvanometric registration (if galvanism is the form intended), the precise points to which the electrodes are to be applied, and the duration and frequency of the application. Besides electric cauterization and electrolysis, we depend upon the definite remedial action of electricity according to the details of its employment. In short, it has been made a thoroughly manageable therapeutical agent.

Among our new therapeutical resources the organic extracts and juices are, indeed, remarkable, not alone for their efficiency as remedies, but also for the light their employment has shed on physiology. Organs like the thyreoid gland, the thymus and the suprarenal capsule, of whose functions we knew nothing a few years ago, have proved to have very definite and important parts to play in the economy. Their use in therapeutics is unquestionably destined to enlarge materially the scope of our remedial power. The list of organs has already been nearly if not quite exhausted by the experimenters, but we may be sure that not all their properties have yet been mastered; that, however, we may look upon as but a matter of a little time.

The theory of the attenuation of viruses, conceived and put into practice by the immortal Pasteur, has resulted, as we firmly believe, in a striking reduction of the world's mortality from rabies. It has been demonstrated to our satisfaction that the Pasteur treatment, employed early enough, is a sure prophylactic, save in a very small percentage of cases, provided the bite inflicted by the rabid animal does not involve parts so situated as to favor the quick spread of the virus to the central nervous system. There are those who deny this, we are quite aware; we are only expressing our own conviction.

A decade or so ago Robert Koch astonished and dazzled the whole civilized world by the announcement that he had succeeded in producing a derivative of the tubercle bacillus which he thought might prove curative of tuberculous diseases. We may be pardoned for here referring to the fact that at the time of his statement that his tuberculin had been perfected we cautioned our readers not to be over-confident of its curative power. It took comparatively but a short time to prove that we were justified in the attitude we had assumed. To the best of our knowledge, we then stood alone in our opinion of the tuberculin treatment. It did, however, prove of some efficacy in lupus and a few other forms of localized tuberculous disease, but was soon abandoned as a remedy for pulmonary consumption; moreover, tuberculin showed itself a useful product as a test of the presence of incipient tuberculous disease in neat cattle, and it is still used extensively in that capacity. Koch's recently promulgated *tuberculinum residuum* (T. R.) is now on trial, with none of the old zeal in its favor, and, we think, with the odds against it.

Before proceeding to consider the antitoxines proper, we must devote a few words to the therapeutical employment of natural and artificial serum. It has been observed that the normal serum of certain animals that are insusceptible to particular infectious diseases, if injected into the human blood current or even into the subcutaneous tissue, confers more or less of immunity against those diseases. This observation has not yet been largely acted upon, but we may look to see it play an important part in the therapeutics of the future. Artificial serum seems to have been first employed by Edmund R. Peaslee as a benign application to the peritoneum in the operation of ovariotomy. His conception of its mode of action is not very clear, but he was a very successful ovariotomist, and we can only conjecture that he builded better than he knew, like many another man. A few years ago much was expected from transfusion of blood, but gradually the conviction has forced iself upon us that it is well-nigh useless, and, indeed, that, on the whole, it is worse than useless. It has virtually been abandoned; so also has the infusion of milk, which had an extremely evanescent vogue a few years since. But experiments in transfusion have not been fruitless; they have culminated in demonstrating the inestimable value of infusions of "normal," or "physiological," solutions of sodium chloride, and not only of infusions, but also of peritoneal irrigation with such solutions. Many a life has been saved by resorting to this measure, even in apparently desperate cases.

To Behring and Roux must the chief credit be given of having worked out the antitoxine treatment of diphtheria and of having thereby not only reduced the mortality from that devastating disease to a point far lower than had ever been attained with any other therapeutical measure, but also greatly encouraged and stimulated work of a similar nature in the direction of getting the mastery over several other formidable infectious diseases, chief among which are tetanus, the Oriental plague, typhoid fever, pneumonia, pulmonary consumption, and septicæmia. We are quite aware that some acute observers, who are at the same time close reasoners, still deny that the anti-diphtheritic serum has any real remedial efficacy, but those who have seen most of it are firm in their conviction of its great efficiency, and theirs, we think, is the general verdict of the profession. If we accept the antitoxine theory as established, we must grant that, besides having strengthened therapeutics amazingly, it has fixed forever our notions of the nature of acquired immunity to infectious diseases.

The open-air treatment of pulmonary consumption is one of the grandest triumphs of the medicine of the nineteenth century. The profession is now thoroughly convinced that tuberculous pulmonary disease is eminently curable in its early stage by such simple measures as rest, with constant exposure to the open air of a salubrious region and a generous diet of highly nutritious food, also that it is curable even in the absence of one or more of these favorable conditions—nay, that it often ends in spontaneous recovery without the assistance of any of them, which fact, however, in no wise excuses failure to press them all into service. The general public is slowly getting to recognize that the consumptive is not necessarily doomed. Facilities for treating the consumptive poor on a large scale are now at hand, or shortly will be, and we may look forward to seeing "the great white plague" conquered within a very few years.

The cold-bath treatment of typhoid fever, the practice of enteroclysis employed in Asiatic cholera, the supporting treatment of pneumonia, the use of the salicyl compounds in rheumatism, the Bad Nauheim system of effervescent baths and resisted exercises for various organic diseases of the heart, the use of antivenomous serum in snake-bites, the elimination of injurious germs from the food of infants as a preventive and curative measure against diarrhœal diseases, the subcutaneous administration of ether in collapse, the parenchymatous employment of antiseptics in phlegmonous inflammation, the use of gelatin in hæmorrhages, the application of ice in sunstroke, the thyreoid treatment of myxœdema, and the preventive treatment of ophthalmia neonatorum are some of the means by which the medicine of the present day saves life and lessens suffering.

In obstetrics, we may point to the virtual extinction of puerperal fever, to the suppression of craniotomy in the case of living children, to the extended use of the forceps, with its immediate abbreviation of suffering and its prevention of ulterior sloughing and fistulæ, to the revival of symphysiotomy and laparo-elytrotomy, to the well-nigh assured safety of the modern Cæsarean operation, to the Credé method of expression of the placenta, to greatly improved procedures for the resuscitation of asphyxiated children, and to the *couveuse* for saving life in the case of puny children and those prematurely born as achievements that have wonderfully reduced both the maternal and fœtal mortality.

Turning to the domain of surgery, we have to record results so brilliant as almost to eclipse the achievements of general medicine, certainly in the estimation of the laity. Buck's "elastic extension," together with James L. Little's substitution of the plaster-of-Paris splint for the old-fashioned starch bandage, has led to the ambulant treatment of simple fractures now so largely practised, and antisepsis has almost abolished the danger formerly incident to compound fractures. Manipulation has well-nigh superseded forcible traction in the reduction of dislocations, to the great diminution of suffering. Crooked bones are made straight by means of osteotomy. Pott's disease of the spine is cured, as is also hip-joint disease, by modern orthopædic procedures. Joints are opened fearlessly under the observance of antiseptic precautions. The reproduction of hopelessly diseased bones is often accomplished by saving the periosteum in the operation for their removal, and osteoplasty has been brought to a high state of excellence. Simpson's acupressure and particularly the Esmarch bandage have been found powerful means additional to those before in our possession for the control of hæmorrhage, and side by side with these ingenious devices we must place Maisonneuve's écrasure and Syme's operation for traumatic aneurism.

In the surgery of the head, trephining has been rendered almost free from risk, and the telephonic probe, cerebral localization, and Roentgen photography have powerfully conduced to the sure and safe removal of foreign bodies from the brain. Cerebral abscesses and tumors of the brain are often successfully attacked, and cranial paracentesis is hardly to be dreaded. Various important ophthalmic operations are now performed with a percentage of successful results deemed unattainable but a few years ago. For example, the extraction of cataract, though practised before the nineteenth century, was not of such well-nigh universal employment as it has now become. Iridectomy has come into use, both as an adjunct to the operation for cataract and for the relief of many other morbid conditions, notably glaucoma. To cite only one of the many advances in the surgery of the ear, the progress made in saving life when it is threatened by such frightful conditions as often attend mastoid suppuration has been nothing short of the marvelous. Deformities of the nose, both the visible and the concealed, are so frequently minimized or altogether done away with by surgical procedures, that surgical rhinology may be said to have taken gigantic strides. Pharyngeal adenoid vegetations, the pathological relations of which were pointed out by Wilhelm Meyer, are no longer, with the surgeon's consent, allowed to stand in the way of robust adolescence. O'Dwyer's procedure of intubation of the larynx, so far superior to Bouchut's abandoned method as to be practically a new operation, is recognized the world over as a life-saving device of the first magnitude. Endolaryngeal treatment, many years ago practised to some extent by Horace Green, who encountered persecution as a consequence, has been so facilitated by Garcia's laryngoscopy that it is a matter of everyday practice. Laborde's device of rhythmical traction of the tongue to stimulate the respiratory center in cases of suspended animation seems to have been the means of saving life in many cases of apparent death by drowning and in a few instances of lightning-stroke, and to constitute a distinct addition to our resources. Thyreoidectomy has come to be a recognized operation and one of great value in cases of goiter, but we have learned the lesson that it is unsafe to remove every vestige of thyreoid tissue, lest myxœdema, a recently discovered morbid condition, should result. Fortunately, the demonstration of the strumiprivous origin of myxœdema has been followed by its successful treatment by means of thyreoid feeding, and the scope of this therapeutical procedure has been so enlarged as to take in a number of other pathological conditions.

The surgery of the œsophagus has been essentially a product of nineteenth century progress. External œsophagotomy and internal operations have almost given us the mastery of strictures of the gullet. Stenosis of either orifice of the stomach, too, is now remedied with a close approach to certainty, and even the entire stomach has been removed in several instances,

* New York Medical Journal.

with the result of prolonging the life of the individual. Intestinal anastomosis, with the employment of the Murphy button and other similar devices, has enabled us to remove malignant and other intestinal tumors and constricted areas. Colotomy for the relief of stricture of the large intestine has within recent years been elevated to the rank of an operation that we need feel little hesitation in resorting to. Willard Parker's abdominal section for abscesses consequent on disease of the vermiform appendix has developed into the formal procedure of removal of the appendix, an operation now in common use throughout the civilized world and acknowledged to be one of our most precious means of saving life. Kraske's bold invasion of the rectum by partial resection of the sacrum has materially enhanced our power of dealing successfully with many cases of serious disease of the lower intestine.

In thoracic surgery the prominent advance has been in the evacuant treatment of pleural empyema, including Estlander's operation of resecting a portion of one or more of the ribs, a procedure that has rescued many a sufferer from the grave. It is too early yet to estimate the ultimate results of John B. Murphy's plan of treating tuberculous pulmonary disease by distending the pleural sac with nitrogen and thus compressing the crippled lung for a time and giving it the rest so needed for its restoration; it is a logical procedure, it must be conceded, and one that seems likely to pave the way to a successful surgical treatment of consumption, even if it does not in itself turn out to be adequate to the purpose. Unhappily, cancer of the breast is still one of the great obstacles to long life among women. Surgical operations for its eradication have of late years grown much more thorough than they formerly were, but the mortality is still fearfully high. It may be that in the treatment of malignant disease surgery is destined to give place to some curative rather than mutilating process, something that is to grow out of procedures now applied to "inoperable" cases. William B. Coley's success in a fair proportion of such cases may truly be said to be encouraging, and we have not the slightest doubt that cancer will yet be conquered.

The surgery of the gall-bladder and, indeed, that of the liver itself have met with the most promising successes within the last few years. That of the spleen, its entire removal, is also encouraging. Operations for the radical cure of the various forms of hernia are now of everyday occurrence; they are fraught with little danger and in a large percentage of cases they give excellent results.

The surgery of the urinary tract has been wonderfully developed during the century. Allarton's median lithotomy and Syme's external urethrotomy were among the earlier advances, with Civiale's lithotrity, to be succeeded by suprapubic cystotomy, Bigelow's litholapaxy—an immense stride—and Bottini's operation for prostatic hypertrophy. Nephrotomy and nephrectomy are to be added, with the various procedures for relief in cases of floating kidney and with ureteral implantation.

Surgical gynecology is a creation of the century, and it is hardly going too far to say that it has sprung from Marion Sims's brilliant initiative. Sims's early successes in the closure of vesicovaginal fistulæ proved the initial step in a series of operative procedures that have decidedly reduced invalidism among women. Byrne's galvanocautery amputation of the cervix uteri and Freund's operation for the removal of the entire uterus have doubtless saved many lives, and certainly have in numerous instances substituted euthanasia for lingering and hopeless wretchedness. Emmet's uterine trachelorrhaphy and the various improved operations for perineal laceration have proved a boon to countless thousands of women. Lawson Tait's operation for the removal of diseased Fallopian tubes, too, has relieved an amount of suffering that is beyond computation, and is not infrequently a life-saving measure. Ovariotomy stands by itself, technically a gynecological operation, but really an achievement of general surgery. Originally a product of American ingenuity, devised by McDowell and carried to a high state of perfection by Peaslee and Atlee, it was in the highest degree promoted by Sir Spencer Wells, with whose painstaking estimate of its benificence in prolonging life we are all familiar.

Almost every operation in surgery has been rendered decidedly safer than it was before by Listerian asepticism, which may take rank side by side with anesthesia in importance, the two being the chief elements that have conspired to render possible the surgery of the present day. Each of them has undergone elaborate development. In the case of Listerism, some of Lord Lister's early appliances have been found to be unnecessary, and one of them, the carbolic acid spray, was long ago decided to be injurious, but the modifications that have been found desirable, no matter by whom they have been suggested, detract not at all from the credit to which Lister is entitled. In the case of anesthesia, ether did not long remain the only agent known to be capable of producing it; so speedily did Simpson demonstrate the availability of chlorcform, and so worded were some of the early accounts of his demonstration, that a large part of the world was for a long time under the impression that Simpson was actually the discoverer of anesthesia itself. For many years ether and chloroform remained practically the only available anesthetics, as they are still the ones most generally employed. To prove to the profession the great risk of chloroform anesthesia as compared with that procured by means of ether was a task that it took many years to accomplish, and quite as long a time was required to do away with the smothering method of administering ether. Most meritorious work has recently been done in bringing general ether anesthesia to a high degree of efficiency and stripping it of its disagreeable features by means of the preliminary use of nitrous oxide. The professional anesthetist is almost indispensable for the satisfactory conduct of this elaborate method of inducing insensibility, but that specialist has surely a legitimate place, and he will certainly hold it. The various means of producing local anesthesia, such as freezing the part, the use of cocaine, and Schleich's infiltration method, are all precious resources and of wide ranges of usefulness, but it is doubtful if general anesthetization will ever cease to take precedence over them for major operations. Endomeningeal spinal cocainization, while highly creditable to the ingenuity of its inventor, J. Leonard Corning, seems to be unlikely to come into general use, for there are grave objections to it.

In few directions has the advance of our beneficent work been more conspicuous than in the care of the insane. While we fear it cannot yet be said that there are no lunatic asylums in which humane treatment of the inmates is invariable, we may safely affirm that in the great majority of them not only is kindness uniform, but insanity is really treated with a view to its cure. Auxiliary laboratories, notably the institution maintained by the State of New York, seem certain to contribute powerfully to the alleviation and cure of mental disease.

Medicine has borne its full share in the century's mitigation of the horrors of war. Camp sanitation, scientific adjustment of the ration to the work to be performed, supervision of the clothing and bedding, flying ambulances, "first aid" corps, the individual first aid dressing packet, rescue of the wounded under fire, the systematization of field hospitals and general military hospitals, skilled systematic nursing, hospital railway trains, roomy and well-equipped hospital-ships, and salubrious quarters for convalescents are some of the means that the nineteenth century has adopted for ameliorating the lot of the soldier and the sailor—all brought about mainly if not solely by the efforts of medical men. Largely as the result of recent war, northern nations have been made to feel the importance of tropical diseases in warfare and in commerce, and the medical profession has promptly undertaken the necessary study of tropical medicine, which must henceforth constitute a feature in the school curriculum.

The century has witnessed the entrance of women into the ranks of the medical profession. This has been practically unopposed by medical men, at least in our own country, although it was known that it would play an important part in adding to the constantly-growing difficulty, for the majority of physicians, of earning a living. Not only have the men of the profession acquiesced in this new accession of rivals in practice, but they have cheerfully, nay, enthusiastically, done their part in educating women in medicine. Women are now freely admitted to medical meetings, and in the case of many societies to membership, on a full equality with men. We all feel that this throwing open of the doors to women is just, injure our pecuniary prospects how it may. We feel bound to add that the women physicians of the present time are generally recognized as a creditable part of the profession.

In another way women richly deserve mention in this sketch. Much of the success of the medicine and surgery of the closing years of the nineteenth century has undoubtedly been due to the trained nurse. She has been a veritable support, a strong arm to lean upon, in thousands of cases that might else have overwhelmed the physician with anxiety. The lot of man is made tolerable by compensations. If women have seized upon a portion of men's means of livelihood, none the less have women lightened men's burdens and made men more capable of extracting the utmost from that portion of the field still left to them. Physicians will always cherish the memory of Florence Nightingale.

We are not now multiplying medical schools; we no longer hold out allurements to young men who fancy they would like medicine as a vocation. We are striving to improve our schools and to admit to them only such students as are shown to possess already the mental equipment necessary to the adequate study and worthy practice of an arduous profession, one full of anxieties and difficulties, but on the whole, happily, one that is most honorable and beneficent. Our teaching methods and facilities are constantly growing more efficient and our requirements more and more exacting. The time was, and that not very long ago, when a bright lad might pick up without much exertion a smattering of medicine and meet with material success in medical practice, but that was because his rivals were apt to be no better equipped than himself and lacking his brightness. All that has been changed; there is now no royal road to the medical degree, except in a constantly dwindling number of unenlightened localities, and the degree itself must in an increasing number of communities be supplemented by a rigid governmental examination. The fashionable physician of the past—he who traded on his deportment, his sympathetic air, or his assurance—is fast becoming extinct. The medical graduate of the present day is necessarily learned; when to learning he joins wisdom, which no man can teach him, he is sure to succeed in the practice of medicine. Fortunately, however, there is no chance for a learned fool. The advances in education and in the requirements for the license to practice must be set down as among the most positive strides of nineteenth century medicine.

It remains for us to speak of the supreme achievement of the medicine of the nineteenth century—preventive medicine, the ceaseless effort to stamp out disease. What other body of men than the medical profession has ever bent its energies to the task of annihilating its own means of existence? Without disease there is no need of doctors. Disease there will always be, no doubt. It will come in new forms. In the century that we have been reviewing there have come, or been revived, influenza—that protean and hellish disease—diphtheria, epidemic cerebro-spinal meningitis, and the Oriental plague. Diphtheria we have virtually conquered; the twentieth century must struggle with the others and with such still newer minions of death as will come upon mankind during the hundred years that are to succeed the present day. If sanitation had been thrust upon us from without, and we had simply acquiesced—had bowed to the inevitable, so to speak—we could take no particular credit to ourselves, for mere artisans, even the much-abused plumbers have done that much; but the medical profession has itself been the prime mover in every effort to blot out disease from the face of the earth, and, resting their pretensions on that glorious fact, physicians may confidently trust to the coming historian for that exaltation which shall more than take the place of material reward. Proud as we are, however, of what we have achieved in the nineteenth century, we should be rash in the extreme to attempt to forecast the glory of our successors in the next hundred years.

AMERICA'S PRIMACY IN IRON AND STEEL.

IN a recent monograph on the iron and steel trade of the United States, issued by the Treasury Department, attention is called to the fact that the United States is now the world's greatest producer of iron and steel and coal as well as of copper, cotton, breadstuffs, provisions and many other articles entering into the daily requirements of man.

In a comparative survey of the world's iron ore situation, the remarkable fact is brought out that the United States in 1899 produced 30 per cent of the world's ore, or 25,000,000 tons out of a total of 85,000,000 tons, in round numbers. This quantity is somewhat less than the combined ore output of both Great Britain and Germany, including Luxemburg, which produced respectively 17 per cent and 21 per cent of the world's ore supply. This alone gives the United States the leadership among the world's great ore producers; but this fact must be taken in connection with coal production, upon which the iron industry depends and of which this country produces 32 per cent. of the world's output, while Great Britain produces 30 per cent. and Germany 19 per cent. With primacy in coal and iron ore, the position of the United States is one of undisputed and permanent ascendancy in her control of the raw materials of iron and steel production.

This primacy in raw materials gives the United States a self-sufficing position, as compared with that of her foremost rivals—Germany and Great Britain. While the Dortmund (Germany) furnaces have to go to Northern Sweden for iron ores and the furnaces of Cleveland (England) have to get their ores from Northern and Southern Spain, the United States is far freer to locate her iron and steel industries with direct regard to the conditions of maximum economy in the accumulation of raw materials and the distribution of the finished products. Therefore, as coke has displaced coal, the tendency the world over is for the furnace to leave the colliery and move toward the ore mines. Hence the iron and steel industries of this country are gradually being drawn around the southern shores of Lake Erie, within easy access of the vast ore deposits of the Lake Superior mines. The preponderance of this single source of ore production is apparent from the fact that the Lake Superior region furnished 73 per cent. of the 25,000,000 tons of ore consumed by our furnaces in 1899, while the Southern States furnished 19 per cent. and the Eastern States but 8 per cent. One of the most wonderful developments in modern trade is that of the ore-handling facilities from the Lake Superior mines to the furnaces of Ohio and Pennsylvania.

Among the world's great pig iron producers the United States first attained the leadership in 1890; but in 1894 lost it to Great Britain again, only, however, for the time being. In 1895 the United States finally outranked the United Kingdom. In 1899, the five great pig iron producers stood in the following order of importance:

Countries.	Tons.
United States	13,620,703
Great Britain	9,305,319
Germany	8,142,017
Russia	2,672,492
France	2,567,388

The development of a domestic consumptive capacity has been a feature of the national policy toward the iron and steel trade. It has been followed by the growth of a national demand unequaled by any other nation. The volume of demand thus developed has resulted in that gradual reduction in the cost of production which has brought this country fully equipped to enter the world's markets and is, therefore, not ephemeral but enduring, because it is based on a highly developed and rapidly enlarging home market such as no other nation now enjoys.

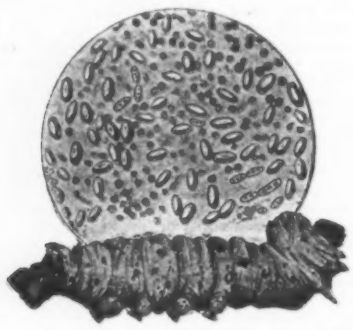
The transition from the iron to the steel age is indicated by the substitution of steel rails for iron rails in railway building. Here again the United States holds the primacy, because of her producing almost 40 per cent. of the world's steel output, while Great Britain produces 18½ per cent. and Germany 21 per cent. No other nation converts so much of its pig iron into steel as the United States does. Of the world's pig iron output, 40,000,000 tons, 70 per cent. is made into steel; whereas this country converts 77 per cent. of its pig iron tonnage into steel, amounting to 10,636,858 tons out of the world's total output of 27,110,000 tons. The United States is the foremost steel-consuming country of the world, a single city having consumed 125,000 tons in a year for building purposes alone, and one car company having required 400,000 tons of steel to meet its yearly contracts. In 1879 about one-third of our pig iron was made into rails, but since that date steel rails have ceased to be the chief form of steel production, their proportion in 1898 being but one-sixth of the whole. The consumption of steel per capita for non-rail uses in 1879 was 75.4 pounds; in 1889, 213.2 pounds; in 1898, 276.2 pounds, showing how other than rail uses of steel have developed in 20 years.

In our iron and steel trade with foreign countries covering the last 20 years our position has been exactly reversed. Within the last five years we have actually changed from an importing to an exporting nation. In 1880 we imported five times as much in value as we exported of iron and steel products. Now we export six times the value of our iron and steel imports. These exports in 1900 aggregated $121,858,341, thus ranking next to breadstuffs, cotton

and provisions, the three higher in value. There are in the iron and steel exports 21 classes valued at from $1,000,000 to $9,000,000 each.

THE SILKWORM.

THE production of silk was unknown in Europe till the sixth century, when two monks, who brought some eggs of the silkworm from China or India to Constantinople, were encouraged by the Emperor Justinian to breed the insect and cultivate its cocoons. Several silk manufactures were in consequence established in Athens, Thebes and Corinth, not only for rearing the worm upon mulberry-leaves, but for unwinding its cocoons, for twisting their filaments into stronger threads and weaving these into robes. About 1130, Roger II., King of Sicily, set up a silk manufacture at Palermo and another in Calabria. From these countries the

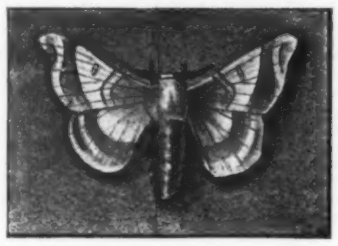


WORM ATTACKED WITH THE PEBRINE; SURROUNDED BY A MICROSCOPIC FIELD SHOWING CORPUSCLES.

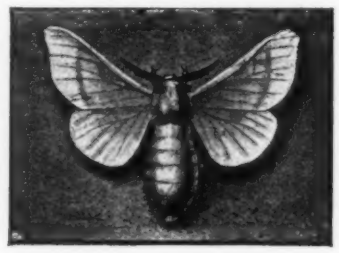
silk industry soon spread throughout Italy. It seems to have been introduced into Spain at a very early period by the Moors, especially in Murcia, Cordova and Granada. The French, having been supplied with workmen from Milan, began the silk manufacture in 1521, but it was not until 1564 that they began successfully to produce the silk itself. In France, at present, the breeding of silkworms is an agricultural industry which is conducted concurrently with other kinds of work upon an infinite number of small farms. It may be said that with the majority of the one hundred and sixty thousand French breeders, it occupies the interval between two periods of intense activity.

The silkworm, the Bombyx mori of entomologists, was called by Guerin Meneville, in allusion to the very remote date of its domestication, "the dog of insects." It is just to observe that long servitude has weighed heavier upon this lepidopter than it has upon the above named quadruped, and has ended by robbing it of a great part of its strength and address. In fact, the certain number of eggs, which are technically called "graina." These, when closely examined, exhibit a transparent gummy varnish through which it is seen that they are of a pale yellow color. Although very small and extremely light, they absorb oxygen and exhale carbonic acid—in a word, they respire like living beings, and, by that very fact, require special care. That is why breeders, immediately after oviposition, hang from the ceiling of a well-aired room the cloths to which the eggs are attached, through their viscous envelop. The eggs may remain suspended in this way up to the period at which the cold of winter moderates their respiratory activity and benumbs them. Then ensues a sort of lethargy during which they remain indifferent to shocks, to want of air and humidity, and even to the most intense cold.

It might be said that the egg needs this sensation of cold, which benumbs it, in order the better to collect its forces and preserve the energy which it will put forth later on at the first signs of spring. But, since the warmth of spring, if premature, might awaken the



MALE MOTH.



FEMALE MOTH.

eggs from their slumber before the cold period has expired, it is for the breeder's interest to prolong the period of hibernation as much as possible. At present, this is rendered easy through special apparatus called "hibernators."

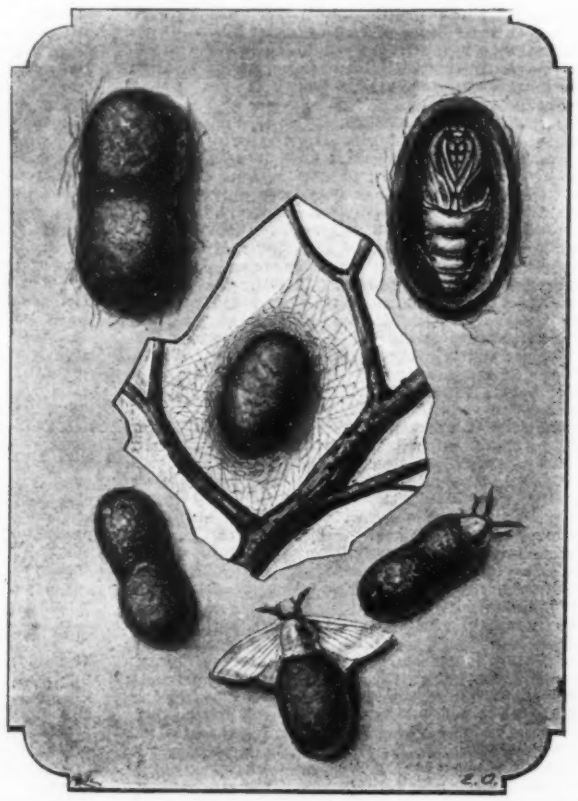
The first heat of spring excites the work of the cells of the egg and hastens the evolution of the embryo. The latter, which up to now has existed in the form of a semicircle scarcely visible under a lens, becomes more and more differentiated at the expense of the contents of the egg, gradually absorbs all this semi-fluid provision, and becomes converted into a small band which, having soon become a larva, will leave the white shell in which it is imprisoned. In order to cause such development, recourse is had to artificial heat. Formerly, such heat was found beneath the clothing of women or in well warmed beds. At present, breeders on a small scale employ incubators—small copper or osier apparatus in which the eggs are submitted to a temperature of, say, from 15 to 20 degrees. In rearings on a large scale, there are used for incubation special compartments heated by stoves.

seen to be as sharp as the quills of the porcupine. These worms, scarcely three one-hundredths of an inch in length, crawl about the drawers of the incubator and over the eggs that are as yet unhatched. The latter are freed from them by an artifice. The breeder, in fact, covers the drawer with a piece of bobbinet upon which he places some very tender buds of the mulberry tree. The young insect, being attracted by the odor, crawls up the sides of the drawer and traverses without difficulty the meshes of the bobbinet, and begins to devour the food that has been served thereon. After the buds have been sufficiently nibbled, the little black worms are carefully taken up and placed on small scaffoldings of wickerwork, the bottom of the shelves of which is covered with white paper, and which are kept in a room heated to a temperature of 24 degrees. The worms are very voracious from the very time of their hatching, and require to be fed constantly.

Five days after their escape from the egg, the appetite of the insect doubles. This is the sign of a coming event of great importance that will be repeated four times during the short existence of the larva, and that is called "moulting." It is a transformation necessitated by the exigencies of the development of the worm, the first rigid skin of which becomes, so to speak, a sort of strait jacket that cannot stretch beyond a certain point. This change of toilet, which requires considerable labor, does not take place without a sort of penitence. On the sixth day, in fact, the worm crawls about languidly over its food without eating any of it, and, thanks to the abundant flow of a viscid exudation, attaches its legs to the leaf that bears it. Then it becomes yellow, ceases to eat, keeps the top of the body humped and remains immovable, and thus marks the beginning of moulting by a quasi-cadaveric inertia.

Its skin soon shrivels and detaches itself in very thin sheets. The exfoliation begins at the horny part that forms the nose, and reaches the scales of the front of the head, which disappear and permit of the protrusion of a new head with a more elongated nose. Finally, the legs disengage themselves. At this mo-

ADULT SILKWORMS.



COCOONS; IMMOVABLE CHRYSALIS; MOTHS ESCAPING FROM THEIR PRISON.

moth of the silkworm, which in a wild state must have had a powerful flight, can no longer sustain itself in the open air upon the inclined and movable leaves of the mulberry tree when agitated by the wind. It is no longer possible for it to protect itself against the heat of the sun and the attacks of its enemies. The female, which is always immovable, seems to be ignorant of the fact that she has wings. The male no longer flies, but merely flutters about his companion without leaving the ground.

The Egg.—During the course of the month of July, the female of the European breeds lays a

As a general thing, matters are so arranged that hatching shall take place at the epoch at which the mulberry trees are putting forth their first leaves, so that the young worms may find food appropriate to their age.

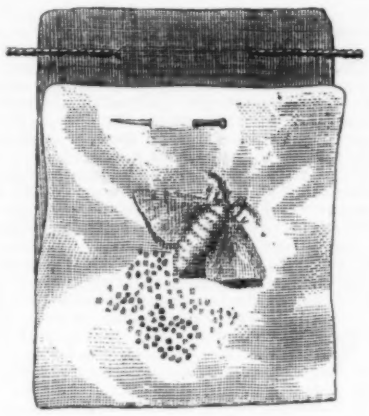
The Worm.—Toward the eleventh day of incubation, the egg begins to change color. Its lilac tint fades and gives way to a whitish shade. This is the moment for raising the temperature to 22 degrees. Three days afterward, the gaping shell gives passage to a minute worm-like animal of a beautiful black, as brilliant as jet, covered with black hairs which, under a lens, are

ment, the most difficult part of the operation is finished; the worm has found a bearing point, and a few contractions permit it to cast off the old skin. At the end of from twelve to twenty-four hours, the caterpillar has completed its moulting and is very weak, and needs rest in order to give its new skin time to dry. In vigorous worms, such rest is limited to a quarter of an hour, after which the insect begins to seek food.

The insect's appetite augments, and the worm visibly increases in size; but, after a short time, its voracity abates, and, at the end of the fourth or fifth day,

the worm becomes immovable. This is the second moult. The third and fourth are separated by intervals of from six to seven days. After the fourth moult, the worm attains its largest dimensions, reaching a length of about three and a half inches and a weight of from 60 to 75 grains.

Two or three days after the last moult, the worms literally devour the food that is supplied to them. In four days, the caterpillars coming from the eggs of a single moth will consume about nine pounds of mulberry leaves, say nearly half of the entire food necessary for their rearing, which usually lasts thirty-two days. At the end of the sixth day, after the fourth moult, the worm's insatiable gluttony has abated, and if it is desired to examine the animal closely it will be necessary to make haste, since it will soon crawl up the branches in order to imprison itself in its cocoon. At this moment, its aspect is very curious. Two large



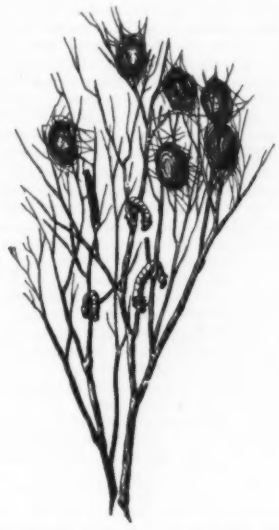
FEMALE MOTH IMPRISONED IN A TARLATAN BAG.

eyes are placed at the end of a cylindrical body, ending at the other extremity in a long, straight horn and supported by two legs. In front, there are three pairs of pointed hooks designed to grasp the leaf. These are the true legs that will be afterward found in the moth. In the center and at the rear, the body rests upon four pairs of more widely spaced appendages, mamillate in shape, and hollowed out beneath so as to form so many suckers by means of which the animal fixes itself to objects. The legs, true and false, are therefore fourteen in number. Since the larva does not respire through the mouth, the sides of its body are provided with a certain number of apertures that give free access to the air. Finally, under the arch of a relatively large cranium, its globular head is provided with a set of mandibles admirably adapted for seizing and cutting food.

Upon opening the abdomen in order to isolate the organs that participate in the principal functions of the larva, we find in the first place a large cylindrical canal of unequal diameter extending from the mouth to the anus, performing the role of œsophagus, stomach and intestine, and representing the larva's digestive apparatus. Two salivary glands flank the anterior part of this tube, which is enveloped by a very thin membrane in guise of a peritoneum.

The circulatory apparatus is of the simplest character. The blood does not circulate in distinct vessels, as in the larger animals. Nor is it regulated by a central organ such as the heart. It consists of a sort of chyme moving in the folds of the peritoneal membrane. While the sanguine liquid of the back is proceeding to mix with that of the folds of the membrane, it bathes the ramifications of a certain number of respiratory tracts, the hollow branches of which end in a single trunk which opens externally through one of the apertures in the side of the body. These branches, which perform the part of lungs, and, at the same time, hold the viscera in their place, permit the blood that bathes them to come into contact with the oxygen of the air. All these apparatus are under the direct dependence of a very simple nervous system.

Upon freeing the body of the caterpillar of all the organs just mentioned, we find that the digestive tube concealed from us two long brilliant guts arranged in numerous folds and becoming thinner in measure as they approach the mouth. This, in fact, is the laboratory in which silk is manufactured and in which the work is distributed in the most rational manner. One section of this organ manufactures only the silk liquid properly so called; another secretes around this substance a protecting material which is soluble in boil-



WORMS KILLED BY THE FLACHERIE.

ing solutions of soap; while a third, which terminates at the mouth, covers the thread of silk with a sort of waxy varnish and at the same time serves as a spinneret.

A final anatomical detail will explain to us how the insect can live in the state of a chrysalis and moth without taking any food. The reason is that during the larval period a large supply of fat accumulates around the respiratory tract and, so to speak, constitutes a food which, in burning, keeps up the breath of life in the insect, which is deprived of a mouth in the last stages of its evolution.

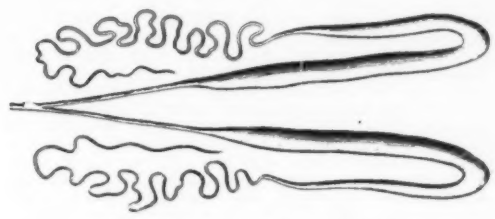
The Alimentation of the Worm.—While grasses or other forage plants perfectly answer the alimentary requirements of the different animals, large and small, of the farm, the silkworm, as small as it is, needs for its alimentation cumbersome plantations of an exotic tree of which it eats the leaves. There need be no astonishment at the term exotic that we apply to the mulberry tree, since the species that has been known in Europe from remote antiquity and that is planted for its black fruit and its thick foliage, is merely the cousin german of the white mulberry. This species, which is more valuable and useful, exists in a wild state only in China. It produces an abundance of tender leaves that give silk a notably superior quality. The tree is propagated from seeds, which are sown in light and humid earth in the month of May.

After the young plants cover with their pale verdure the small plot in which the seeds were sown, they are transplanted in order to give them more space. After they have become shrubs, they are again transplanted. Of such plants, there are ordinarily formed two lots, one of which will form a shrubbery in a sheltered place, and the other will serve for giving full grown trees. The shrubs have the advantage of giving, long before the trees, a crop of very nourishing leaves, which seem to have been created expressly for facilitating the attack of the young worms from the time of hatching up to the second moult. For rearing the worms derived from an ounce of eggs, up to this period, it requires the product of about a hundred shrubs.

Starting from the second moult, the worms are fed upon the leaves of the mature tree, the crop of which is rendered more abundant through grafting and pruning. The quantity of leaves necessary to feed a colony of thirty thousand worms, derived from 450 grains of eggs and from which will be produced from 130 to 140 pounds of cocoons, represents approximately the annual crop of 15 trees more than twenty years old.

The Diseases of the Worm.—In the rough sketch of the development of the silkworm given above, we have supposed that the larva has succeeded in crawling up

POSITION OF THE WORM WHILE MOULTING.



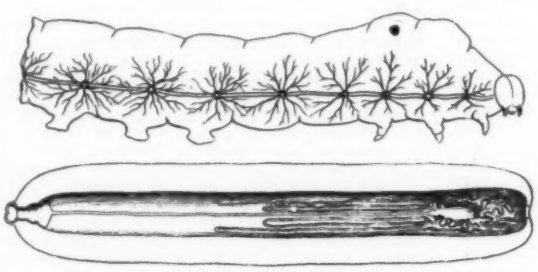
GLANDS OR SILK ORGANS.

the branches without impediment. Unfortunately, this is not always the case, and if we now succeed, in the rearing of the silkworm, in solving a problem that has heretofore vainly solicited the efforts of human societies, it is because of the labors of our scientists and of the talent of our silkworm breeders.

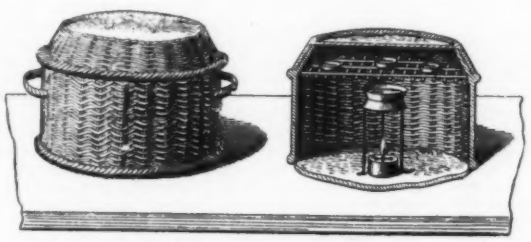
Of all affections of the worm, the most formidable is undoubtedly the "pebrine," a disease which, had it not been for the genius of Pasteur, would have destroyed the European breeds of the silkworm, and probably silk culture itself. This disease assumed a truly epizootic development only in 1849. All at once, in the best conducted nurseries, the worms began to neglect their food, failed to grow and to cover rapidly increasing surfaces upon the frames. Then the softest parts of the body became speckled with black, and the worm at length shriveled and perished. In 1865 the eggs submitted to incubation, with a view to a crop of from 50 to 60 million pounds of cocoons, gave but 8 million. The effective agent of the disease is a microscopic alga that propagates itself in the body of the worms contaminated. The disease is contagious as well as hereditary. Unfortunately, the pebrine is not the only enemy that the worm has to contend with during its ephemeral existence, for there is the "flacherie," and the "muscardine," for example, the latter a disease almost as formidable, caused by a fungus, the Botrytis Bassiana. The spores of this fungus have been detected in the eggs of the Bombyx mori, as well as in the different parts of the body of the insect in all stages of growth.

Hutton attributes the enormous loss of silkworms by muscardine and other diseases, and the consequent diminution of the silk crop, to the combined effects of bad and scanty food, want of sufficient light and ventilation, too high a temperature, and constant interbreeding, for centuries, of a debilitated stock. He asserts that there is no such thing now in existence as a perfectly healthy domesticated stock of silkworms.

The Chrysalis and the Cocoon.—The ravenous hunger of the worm is soon followed by a passive state



RESPIRATORY TRACTS AND DIGESTIVE APPARATUS OF THE LARVA.



WICKER INCUBATOR.

THE VARIOUS AGES OF THE SILKWORM LARVA.

during which it eats scarcely anything and seems to be specially occupied with digesting. Its silk reservoirs became gorged and finally occupy the greater part of the anterior cavity of the abdomen. Its entire body becomes translucent and a large drop of liquid puts an end to its dejections. The worm, having become lighter, thinner and longer, refuses the leaf, wanders here and there and tries to ascend. Then, after wandering on all sides, it finds the branch of the heath that has been planted at the sides of the frames, ascends and secures its body thereto by means of an irregular network of threads, and leaves an ovoid space which it actually begins to line by discharging silk from its inflated glands.

It is curious to observe this little laborer while it is constructing its silken abode. The head and front part of its body are animated with a regular swinging motion, while the legs in a circle preserve complete immobility. The position is soon slightly varied and the same work is begun at a slight distance. At the end of five or six hours the ovoid space is closed on all sides. We have thus the rough outlines of a cocoon formed of a silky envelop, thin and transparent, through which the motions of the insect can be distinguished. But the latter, continuing to line the interior of its dwelling, soon becomes hidden from the sight of the observer.

After the cocoon has been finished, that is to say, at the end of three days, the worm inclosed in it falls into a state of complete immobility—into a torpor capable of giving the illusion of death. The rings of the body approach each other through the foldings of the skin that separates them, the animal contracts, and its false legs and its horn dry up and fall off. Under this apparent mummification, not only does life continue, but evolution proceeds. The sides of the upper rings soon exhibit two swellings, the signs of coming wings. At the same time, a new skin is forming beneath the old one. Three days after the completion of the cocoon, the animal, leaving its half dried skin, disengages itself under the form of an ovoid almost inert mass, the appendages of which are glued to the body. This is the nymph or chrysalis—an odd state, a strange vital situation, standing midway between the caterpillar and moth stages.

Its body, however, soon hardens, and the liquid that flowed over its skin becomes a sort of sticky varnish—a brownish carapax. Under this rigid envelop, the internal organs of the nymph liquefy and form a sort of "bouillie" that will serve for the reconstruction of the organization of the animal upon a new plan.

It will be understood, then, that during this period the deceptive slumber conceals a very active internal life. In the meanwhile the animal is respiring and its blood is circulating; it is assimilating certain substances and is secreting or exhaling others. If care be not taken it will proceed to break the threads of its silken nest in order to effect its deliverance. But, since a pierced cocoon cannot be reeled, it is important to asphyxiate the insect before it accomplishes its last transformation. For this operation, recourse was formerly had to the baker's oven, but at present, use is made of special apparatus that surely kill the chrysalis without altering the new silk.

The Moth.—There are cases in which it is of interest to continue the rearing until oviposition by the moths. This is when it is desired to obtain eggs. The cocoons are then placed in a cool, darkish room which never receives the direct rays of the sun. The prisoner soon divests itself of its covering, and its head, which is the first to become disengaged, abuts against the upper part of the cocoon, upon which its mouth deposits a few drops of an alkaline liquid that unglues the silken threads. These latter having been pushed aside by its legs, the animal first sticks out its head and then enlarges the aperture sufficiently to permit of the exit of its entire body.

The moth of the silkworm is heavy and its abdomen appears to be swollen. The male, which is smaller and relatively lighter than the female, flutters around the latter for a few minutes after coming from the cocoon. In order the better to seize her, the lower part of his body is provided with two rigid horns which act as claspers.

The silk nurseryman receives the couples upon clean frames covered with paper, and takes care to carry the female in a small bag, as shown in one of the figures. The oviposition begins immediately after the separation of the sexes.

The moth, destitute of a mouth, takes no food, and, in order to live, consumes its own tissues. This leads to a quick death.

The Silkworm Nursery.—The art of rearing silkworms is reduced to knowing how to select the eggs and cause them to hatch, how to protect the insects from the inclemencies of the weather and from dirt, and how to collect the cocoons in order to send them to the asphyxiating apparatus. In an exploitation of slight importance, this is not very difficult, but in one upon a large scale it is impossible without the exercise of great intelligence.

In the centers in which the silkworm is reared special structures are used for the housing of the insect. Nevertheless, a room, a hall, or several connected apartments may be converted into a nursery, provided they be well exposed, well situated and well ventilated. It may be conceived, in fact, that in places in which live thousands of worms and in which stay those who have to take care of them, and in which accumulate excrement and the detritus of leaves, the air is liable to become quickly corrupted. To renew it by opening the windows and doors is not always possible, since the external air may be stagnant, and it is not always prudent, because the air may be cold. It therefore becomes necessary to ventilate the rooms by means of special arrangements. But the silkworm, like certain exotic plants, can develop only in an environment that is both warm and humid. Apart from the lighting, the nursery should, in a manner, realize the conditions of a hot-house. Heating apparatus therefore play a prominent role in its installation.

In small nurseries, a chimney may, while ventilating the room, warm it properly; but, if the rearing chamber is very large recourse is had to one or more stoves, or, better still, to hot air apparatus placed in the basement. The interior of the apartment should be pervaded with a certain amount of humidity, without being saturated therewith. The furniture, which is very simple, although very cumbersome, consists principally of a certain number of wicker frames about thirty inches square fixed at a distance of from sixteen to twenty inches apart upon fixed or movable uprights. A frame surface of 20 square feet is necessary for every 15 grains of eggs.

The frame serves as a bedroom, dining room and toilet room for the worm. It is here that it is fed, and it is here too that it changes its skin and accomplishes all its functions. A room devoted to so many uses requires incessant vigilance in order that perfect cleanliness may be preserved; so the frames, especially during the last weeks of the rearing, are the object of infinite care. When the worm is approaching maturity, these frames serve as a support for the branches which the insect ascends in order to spih its cocoon. Various trees or shrubs of the forest furnish branches which, stripped of their leaves, may be used to form a hedge up which the insect can crawl in order to suspend therefrom its silken prison.

The worm spins its cocoon at the end of three days in a temperature of from 22 to 25 degrees C.; but, since the ascending of all the insects does not take place simultaneously, and another three days are necessary for the transformation of the worm into a chrysalis, the cocoons are not entirely finished and ready to be detached from the branches until ten days after they were fixed to the wood. Before placing them in baskets, after they have been detached, the floss that covers them is removed, and the cocoons are then sent either to the smothering apparatus or to a cool and dimly lighted chamber, according as they are designed for spinning or rearing purposes.

The spinning mill draws from fresh cocoons a quantity of raw silk thirteen or fifteen times less than their weight. So the annual product of the French cocoons in raw silk may be estimated as being over 1,160,000 pounds.

Total Production.—The production of silk, which is circumscribed in the zone of the mulberry tree, may be estimated at more than 50,000,000 pounds a year, derived from, say, more than 660,000,000 pounds of cocoons. The contingent furnished by Europe is small as compared with that of Asia; but, while Europe consumes twice more than it produces, Asia exports a third of it. As for America, that demands annually over 4,000,000 pounds of silk from Asia and over 1,000,000 pounds from Europe. For the above details and the illustrations, we are indebted to Le Monde Moderne.

CORN GROWING.

RESULTS OF TWELVE YEARS' WORK AT THE EXPERIMENT STATIONS.

DURING the past twelve years more experiments have been made with corn by the different agricultural experiment stations than with any other farm crop. A mass of isolated information on the various features of the corn plant, its cultivation and uses, has accrued, which it is the purpose of this article to bring together and summarize, giving emphasis to such points as the accumulated evidence seems most strongly to indorse. The discussion here given is confined entirely to field corn. The data have been summarized from 189 Bulletins and 107 Annual Reports of the Agricultural Experiment Stations which report results with corn.

The Corn Plant.—The root system of corn, rate of growth of both roots and stalks, length of growing period and the formation of dry matter in the plant at different stages of development have been studied by a number of stations.

The plant has a remarkably strong root system. Within sixty days from planting, corn roots have been traced eight feet deep and as far aside. The main bulk of roots, however, has been found to develop within eight inches of the surface of the ground. Within this area a dense network of feeding rootlets, reaching from row to row and completely permeating the whole soil area below the cultivated portion is formed. In investigations at the Utah Station it was found that the fourth inch of soil contains a larger amount of roots than the three inches above it or the four inches below it, and nearly as much as both put together.

The method of cultivation influences the development of the roots to a considerable degree. The shallower the cultivation the more surface roots develop. Deep cultivation, on the other hand, forces a more downward growth of the roots. Under methods of cultivation this phase of the subject will be considered further. The depth at which the corn is planted has little if any influence on the depth at which the roots grow.

The rate of growth of the corn plant was studied by the Illinois Station. The average of three years' observation with three dent varieties after the plants were one foot high shows that the most rapid growth in height was made when the corn was between three and six feet tall. During one season stalks grew at the rate of two feet per week for two weeks in succession, the latter part of June. Another season, when planted a month later and retarded in growth by excessive rains, the stalks averaged three inches per day the last week in July. In three years out of four, the plant reached its maximum height eight weeks after it was one foot high. The rate of growth seems to be specially dependent upon the stage of development which the corn plant has reached. Heat has been found an even greater factor in rapid growth than moisture.

A large number of stations have made observations on the length of the growing period of corn. This has been found to vary with the variety, latitude, and other factors. In the latitude of Illinois, 100 days from date of planting may be considered the minimum for field corn to mature fully, while later varieties often require 150 days. Further north some small early varieties may develop in 70 days. Usually 150 days are required for the development of corn in the South.

Many observations have shown that there is relatively little dry matter in corn in its early stages. When the stalks have reached their maximum growth in height they contain only one-half of the weight of the dry substance found in the matured plant, and of the matured plant one-half of the dry matter is in the ears. The Illinois Station found that 100 pounds of young corn plants two feet high contain as much protein and ash as the same quantity of fully matured corn, although young plants have 90 per cent and the ripe plants only 60 per cent of water. The fiber and starch of the ripe plant was nearly ten times that in young corn. The relation of the nitrogenous to the carbonaceous constituents was as 1 : 3 in the young plant and as 1 : 13 in the ripe plant. The leaves and husks contain one-fourth to one-third of the total dry matter of the ripe plant, the stalks about one-fourth and the cob nearly one-tenth. The butt of the stalk contains much more dry matter than the tip.

Varieties.—Tests of varieties of corn have been made at about 35 of the stations. The reported results are remarkable as showing the extreme variation which may occur with the same variety of corn grown under the same and under different conditions of soil and climate and with different fertilizers, exposures, etc. In Illinois one variety planted on thirteen different plats scattered throughout the trial area ranged from early to late as regards time of maturity and from 45.8 to 100.8 bushels per acre in yield. Variety testing, though the most prolific has proven the least valuable part of the experimental work of the stations with corn. We give herewith a list of some of the varieties which have oftenest given the heaviest yields at the different stations.

Dent Varieties. — Yellow — Early Yellow Rose; Leaming, Champion Yellow Dent; Golden Beauty; Nickel Plate; Murdock; Stewart Improved, and Riley Favorite. White.—Cocke Prolific; Blount Prolific; Burr White; Calhoun Red Cob; Mammoth White Surprise; Moseby Prolific; Welborn Conscience; Boone County White; St. Charles White; and Shaw Improved.

Flint Varieties.—King Philip; White Flint; Angel of Midnight; North Dakota; and Gehu.

This list is of little practical value except as giving in the most general way an indication as to the merit of certain varieties. If in a neighborhood a certain variety of corn has been found profitable, it will be advisable to stick to that variety. Other varieties should be tested only on small areas and not planted for the general crop until they have demonstrated satisfactorily their suitability for the locality.

A summary was made by the Mississippi Station of the comparative yields of yellow and white varieties of corn in seven corn-growing States. The figures show that "in a total of 1,267 tests with 490 varieties, the average yield of 217 white varieties has been 2.5 bushels per acre in excess of the yield of 217 yellow varieties, and that at only one of the stations making these tests have the yellow varieties given the better average yield."

The Pennsylvania Station found from a compilation of analyses that the difference in composition of yellow and white varieties of corn did not in any case exceed one-fourth per cent—a variation too small to be of any significance.

The great need of careful selection of varieties on the part of the farmer is well brought out by experiments at the Indiana Station. In a test of 34 varieties at this station "a range (1) of 33 days in the time required to mature the several varieties; (2) of 44 bushels of corn and over 7,000 pounds of stalks in the average yields per acre of the field varieties; (3) of 24 per cent in the average proportion of stalk and ear; (4) of 7.75 per cent in the average proportion of shelled corn; (5) of 23.4 per cent in the amount of shrinkage in a crib; (6) of 18 per cent in the proportion of stalks without ears; (7) of 17 per cent in the proportion of smutted stalks; (8) of 43 per cent in the proportion of unsmutted stalks without ears" was found.

Crossing and Improvement.—Several stations have conducted experiments in crossing. Cross bred varieties of corn have shown a tendency to revert to more or less remote ancestors, and color has tended strongly to pass from one variety to another. At the Illinois Station there was a tendency in the crossed corn to increase in size and yield. Crossed corn of the second year was uniform in type when the parents were similar, but where they were widely dissimilar, as in the cross between sweet and dent varieties, the offspring either reverted to the parent forms or was dissimilar to either parent.

The improvement of the food value of corn by changing its chemical composition is being undertaken at the Illinois Station. The method is to select corn of high (or low) protein content for seed. At harvest time kernels from ears analyzing highest (or lowest) in protein are selected as seed for the succeeding crop. This process is repeated each year, the idea being to fix by inheritance the character sought and obtained in the highest degree. The fat content is being changed in the same way. Thus far differences varying from 0.5 to 1.25 per cent of protein and from 0.67 to 1.45 per cent of fat have been obtained. These variations are believed to show that it is possible to increase or decrease any of the principal constituents of corn by proper selection and thus materially alter its composition.

Plowing and Cultivating.—Experiments at twelve stations indicate that depth of plowing has but little influence on the crop. Subsoiling has been uniformly without profit except at the Nebraska Station, where the subsoil was compact. A moderate amount of early cultivation is favored by the results obtained in numerous experiments. The essential thing in the cultivation of corn is to keep the ground free from weeds and covered with a soil mulch. Results of 56 tests at 17 stations as summarized by the New Hampshire Station, show an average increase of more than 42 per cent resulting from shallow cultivation as compared with deep cultivation. In moist years cultivation is of less importance than in dry years. With light surface cultivation there occurs a greater development of shallow feeding roots. When there is plenty of moisture in the soil these roots make a good development

and the corn plant flourishes; but in seasons of drought they are quickly affected and the plant suffers. Based on the nature of the root development it would seem that level cultivation of corn from two to three inches deep is most logical and this depth is favored by most of the stations.

The effect of deep cultivation on the water content of corn ground has been studied at several stations. The Wisconsin Station has determined definitely in trials extending over a period of three years, that cultivation three inches deep leaves the ground more moist below the soil stirred than cultivation 1.5 inches deep and these results, in part, have been confirmed by the Utah Station.

At the Wisconsin Station the soil was uniformly warmer on plats cultivated 1.5 inches deep than on plats cultivated three inches deep, the main difference being for the first foot 0.82 deg. F., for the second foot 0.59 deg. F., and for the third foot 0.36 deg. F.

A few of the experiment stations have tested the value of a large number of cultural implements for corn. The results show that the kind of implements used is not of so much importance as thoroughness and carefulness in using them.

Root Pruning.—Root pruning of corn has generally proved injurious. In experiments at the Minnesota Station a knife was run around each hill at a depth of six inches and six inches from the stalks. The root-pruned plats averaged nearly three bushels of corn and 800 pounds of fodder per acre less than the plats not root-pruned. In another experiment root pruning one to four times reduced the yield of corn 13.5 bushels and of fodder ¼ ton per acre. These results have been confirmed by similar experiments in New York, Oklahoma, and Illinois. The greatest decrease in these experiments occurred when the corn was dry at the time of root pruning.

Time of Planting.—This of course depends upon local conditions of soil and climate. At the Illinois Station the best results during eight years were obtained from planting between May 11 and 18. Earlier plantings have required more cultivation than late ones. "Within reasonable limits, time of planting seems to have less influence on yield than the condition of the soil at time of planting." At the Indiana Station during eight years the largest average yields were from plantings between May 1 and 10, rather than later. About this same date was found most desirable in Kansas.

Depth of Planting.—From two to three inches is considered the best depth for planting corn. The average results for five years for plantings one to seven inches deep at the Illinois Station show that in general the yield decreased as the depth of planting increased. The best results at the North Dakota Station were secured from plantings two to four inches deep.

Rate and Method of Planting.—Experiments thus far made indicate that where corn is grown for grain thicker planting is more usual in the Northern than in the Southern States. At the stations in Alabama, Georgia, Louisiana, and South Carolina rows from four to five feet apart, with stalks at intervals of three to four feet, were preferred; while at other stations making such tests rows from three to three and two-thirds feet apart, with kernels nine to sixteen inches distant in the rows gave the best average results. With the closer planting occur larger total yields, larger yields of grain, smaller ears, and more nubbins. If the corn is grown for grain the husking of the increased number of smaller ears increases the cost of the harvest; but if the corn is grown for silage and the grain ensiled with the stalks, the smaller ears are no disadvantage. Rows about 40 inches distant, with single stalks three to nine inches apart in the row, are considered the best distance for silage corn at the Pennsylvania and Michigan Stations.

There is practically no difference in the results, whether corn is planted in hills or drills; convenience in planting and cultivating being the chief factors for consideration. The total number of stalks per acre influences the yields rather than their method of distribution. When planted in hills at the Illinois Station, four kernels in hills three feet eight inches apart, each way, gave the best yields of grain. Six kernels per hill gave the best results in Utah.

In Maine the food value of corn was slightly greater when grown in rows 3½ feet apart and kernels 9 inches distant than when the kernels were six or twelve inches distant. At the New York Cornell Station, the largest total yield of forage was obtained by broadcasting, but the feeding value was lower than when drilled or planted in hills. According to the Maine Station, great variation in the amount of seed grown per acre may occur without materially affecting the yield of dry matter in the matured crop. At the Michigan Station, the albuminoid protein content of corn increased with the distance apart of the drilled rows, while the percentage of crude fiber decreased.

Seed Corn.—It has been quite generally believed that seed corn obtained from remote or more northern localities would give better results than home grown seed. The results secured in experiments in Maryland, Arkansas, Indiana, Oklahoma, and Alabama do not sustain this view. On the other hand, they demonstrate clearly the desirability of using only corn for seed which has been grown in the latitude and preferably in the neighborhood where it is to be planted.

A careful selection of seed corn at the Arkansas Station resulted in an average increased yield of 3⅛ bushels per acre over miscellaneous selection. At the Michigan Station fully matured seed increased the yield over 11 per cent, as compared with seed not fully matured.

Kernels from the butt, tip, and middle of the ears have been used for seed at a large number of stations with varying results. The average yield for nine years of corn at the Ohio Station grown from seed taken from butts of ears grown from butt corn, and likewise middles from middles, and tips from tips was as follows: Butt corn, 58.86 bushels; middle, 59.27 bushels; and tip, 58.70 bushels per acre. The average of five years' results at the Kansas Station was 39.74 bushels from butt kernels, 38.52 bushels from middle, and 39.04 bushels from tip kernels per acre. Where planting is done by machinery the grain will be more uniform if selected from the middle portions of the ear. This seems to be the only practical advantage of selecting the seed from the different portions of the ear.

Stripping, Topping and Detasseling.—Stripping off the leaves for fodder during the growth of the crop reduces the yield of corn and it is doubtful whether the fodder thus obtained will pay for the trouble of gathering it. Cutting off the tops above the ears when in good condition for fodder has in some cases decreased the yield and in others it has not. Removing the tassels from a portion of the stalks sometimes reduces the yield, sometimes increases it, and sometimes produces no definite effect. In twenty detasseling experiments at ten different stations the crop was increased in seven instances, decreased in eight, and in five no effect was noted. In general, it may be stated that the increased yields obtained by detasseling are so slight that the practice is of doubtful benefit.

Cost of Growing Corn.—At the Arkansas Station corn plowed three times and hoed twice with manual labor at 65 cents per day and single team at the same rate, cost at the rate of 22¼ cents per bushel for a crop of 30.08 bushels per acre. In Illinois the average cost of corn production throughout the State was determined. All the factors involved in production, from the preparation of the soil to the delivery at the elevator, including the wages of the farmer himself, whether owner or renter, were included in the estimate and a proper allowance made for time lost and for maintenance of the team during idleness, interest on investment, including rent, and allowance for depreciation of tools and machinery. On this basis the calculated cost of production of corn was 19.5 cents per bushel.

Manuring.—Experiments in manuring corn have been carried on at nearly all of the experiment stations with a vast number of different fertilizers and combinations. The results secured are as variable as the soils upon which the corn was planted and the manures used. In a general way it may be stated that barnyard manure is one of the most effective fertilizers for corn. In some of the newer Western States all forms of fertilizers have been uniformly used without benefit, but in the Eastern States better results are obtained by the use of some fertilizer. On the whole it would seem that in the East a complete fertilizer, containing phosphoric acid combined with small amounts of nitrogen and potash, is most likely to give good results. Corn is a rank-growing plant and will readily make use of large amounts of coarse fertilizers. Results secured at a number of experiment stations in the use of green manures would seem to indicate the desirability of a more extended use of such crops as clover, peas, melilotus, etc., for corn.

Irrigation.—Irrigation water, supplemental to the natural rainfall, was applied to corn in continuous culture at the Wisconsin Station during the years 1895-1899, in amounts varying from 5.7 to 26.6 inches. The yield of corn was invariably increased by the use of water, the increase in 1899 amounting to 37 per cent. At the South Carolina Station excessive irrigation produced a succulent growth of corn and decreased the total yield. This subject has as yet received but scant attention.

Harvesting.—Numerous experiments have shown that the dry matter in the corn plant increases as maturity approached and that, therefore, whether the crop is grown for grain, fodder, or silage, much will be lost by too early cutting. On the other hand, stalks allowed to stand in the field after ripening lose considerable dry matter. At the Iowa Station this loss two months after ripening under ordinary field conditions amounted to about one-half of the dry matter and more than one-half of the total feeding value. According to the same authority, "the stover of a crop of corn seems to reach the highest yield and the best condition for feeding at the stage of growth indicated by a well-dented kernel and the first drying of the blades. The grain of a crop of corn seems to reach the highest yield and the best condition for utility at the stage of growth indicated by a well-ripened ear and a few dry blades; and the best time for securing the crop with reference to the highest utility of both corn and stover would be found at a stage of ripening between the above." After the kernels have become dented the total additional increase in dry matter of the whole plant is small and subsequent changes consist chiefly in a translocation of the several forms of matter within the plant. "The plant first elaborated material and then uses this material largely in forming the ear."

At the Kansas Station corn cut in the milk stage yielded 35.5 bushels of grain and 2.4 tons of fodder per acre; in the dough, 51 bushels of grain and 2.4 tons of fodder; when ripe, 74 bushels of grain and 2.7 tons of fodder. These results agreed with those of previous experiments. They have been in the main confirmed by similar experiments at the Illinois, Minnesota, New York, New Hampshire, and Pennsylvania Stations.

The Wisconsin Station recommends the cutting of flint varieties for silage when just past glazing and dent varieties when "well dented;" while the Vermont Station recommends that corn be allowed to stand before ripening as long as it is safe from frost. The Ohio Station found there was little difference in the yield of grain between corn cut and shocked, provided it was sufficiently matured at cutting time, and that left standing.

In the field curing of corn at the Colorado Station, large shocks lost 31 per cent of their dry matter, small shocks, 43, and corn spread on the ground 55 per cent—largely caused by the active fermentation in the seemingly dry and well-cured stalks. At the Oklahoma Station the outside stalks of corn shocks exposed to sun, rain, and wind lost fully one-fourth of their feeding value as compared with the inner stalks. The average loss in dry matter at the Wisconsin Station in ensiling corn was 15.6 per cent and in field-curing the same fodder, 23.8 per cent.

Corn loses in weight when stored. At the Rhode Island Station fifty ears of white capped corn lost 15.5 per cent in weight through shrinkage, while the same quantity of Lackawaxen corn lost 24 per cent when husked November 5 and allowed to hang in a corn crib until April 15 following. Later experiments show a variation in shrinkage of unshelled corn of five varieties from 7 to 22 per cent when allowed to hang in a corn crib from November 23 to March 25 following. In Iowa the shrinkage of corn in a crib for one year amounted to a fraction over 20 per cent.

These data seem to warrant the following cultural conclusions:

1. Plant for the main crop of corn only such varieties as are known by experience to do well in the neighborhood. Experiment on a small scale with new varieties until their worth is proved. Yellow and white varieties of dent are equally valuable as regards yield and feeding value.

2. The chemical composition of corn can be changed and its feeding value improved by selection.

3. Depth of plowing has but little influence on the growth of corn. Subsoiling is not profitable. A moderate amount of cultivation two to three inches deep is desirable. The greatest root development occurs in the fourth inch of soil, hence the value of cultivation only 2 or 3 inches deep.

4. In the latitude of Indiana planting corn two to three inches deep between May 1 and 15 has given the best results. It makes but little difference whether corn is planted in hills or drills, the number of stalks per acre being the controlling factor as regards yield. In the North rows 3 to 3 2-3 feet apart with kernels nine to sixteen inches distant in the rows have given the best results.

5. Root pruning corn decreases the yield and is an unprofitable practice.

6. Use mature, carefully selected corn grown in the neighborhood in which it is to be planted for seed. All parts of the ear are equally valuable for seed.

7. Stripping, topping, and detasseling corn are generally unprofitable practices.

8. It costs 19.5 cents to grow a bushel of corn in Illinois and 22¼ cents in Arkansas.

9. Barnyard manure is one of the best fertilizers for corn.

10. Harvest corn for both grain and stover soon after the kernels are well dented and the blades begin to dry; but before the ears are thoroughly ripened. For silage, harvest flint varieties when just past glazing and dent varieties when well dented.

11. Corn shrinks in weight when stored from 7 to 24 per cent.

TEA AND COFFEE PRODUCTION IN ANNAM AND MADAGASCAR.

RECENT reports by the French Bureau of Foreign Commerce contain statistics relating to the tea and coffee industry of the Protectorates of Annam and Madagascar. The year 1894 was the first in which tea from one of her colonies was offered in France. In that year 7,500 pounds were received from Annam. In 1896 the receipts increased to 10,296 pounds; in 1897 to 13,000 pounds. In 1898 the imports of tea from Annam into France were 42,262 pounds. The figures for 1899 are not yet available, but it is estimated that the exports will not be less than 14,000 pounds. Up to 1892, Annam tea was cultivated only for use among the natives, and the proposition to cultivate it for European consumption seemed a problem. But the consumption of tea in France was increasing very rapidly. From 1,447,655 pounds consumed in 1892, the quantity rose to 1,794,832 pounds in 1898, and it is believed to have increased by nearly another 100,000 pounds in 1899. The supply was almost entirely from China and Ceylon. The tea from Annam is said to equal the finest article produced in China. It is in very general use in the French army in Annam, and it is believed to be only a question of time when it will meet the entire demand in France. The production is daily increasing. The old colonists are going into the business of growing tea, finding it more profitable than any other occupation. The production of coffee on the eastern coast of Madagascar is expected to soon develop into important proportions. In the past it has been insignificant, but the French government has published figures showing that in a short time an estimated crop of 713,000 kilogrammes (1,568,000 pounds) may be looked for. The receipts of coffee from all the French colonies in 1899 were only 963,000 kilogrammes (2,118,000 pounds).

FINDING OF A LETTER OF HADRIAN.

ITS SUBJECT MUCH THE SAME AS THAT OF HIS FAMOUS "ADDRESS TO HIS SOUL."

WHAT purports to be a letter written by the Emperor Hadrian to his dear friend and successor, Antoninus Pius, turns up among the papyri discovered by the Egypt Exploration Fund in the Fayum. It was composed by Hadrian in view of his approaching death. This most interesting circumstance recalls at once "The Dying Hadrian's Address to His Soul," which suggested to Pope his "Vital Spark of Heav'nly Flame." Many more than one hundred translations into English have been made of "Hadrian's Address." That of Prior (1664-1721) is to my mind unsurpassed by any other version in its pathos and delicacy. It begins:

> Poor little quivering, fluttering thing,
> Must we no longer live together?
> And dost thou prune thy trembling wing
> To take thy flight thou know'st not whither?

Although the papyrus is fragmentary, its general meaning is clear to our translators. Hadrian declares his death to be neither unexpected nor to be regretted, nor to be unreasonable; that he is prepared to die; but he misses the tender care and the life of Antoninus. Hadrian goes on to say:

"I do not intend to give the conventional reasons of philosophy for this attitude, but to make a plain statement of facts. . . . My father died at the age of forty, a private individual, so that I have lived more than half as long again as my father, and have reached about the same age as that of my mother when she died."

The known facts of Hadrian's life accord with the foregoing. There is no improbability that his letters should be in circulation in Egypt, particularly as he

at least once visited Egypt and kept himself in close touch with all parts of his empire. Phlegon, his freedman, is stated to have published his letters after his death. The handwriting of the papyrus cannot be later than the second century, which at the furthest brings the manuscript within sixty years from Hadrian's death.

A seemingly peculiar circumstance is the fact that a schoolmaster of that day appears to have copied, at least in part, this letter from Hadrian to Antoninus as an exercise for a pupil; for we note where the clear and running lines from the teacher's hand are repeated in larger and irregular letters by one who is evidently a learner. To save paper, as we would now say, this copy of the epistle of Hadrian is written upon the back of a taxing list. These two circumstances, however, do not in themselves affect the authenticity of so valuable a papyrus, inasmuch as many of our society's best classical fragments from Egypt are upon papyri already used. The fine copy of the fifth book of the Iliad, for example, was written upon the verso of the "Petition of Dionysia," itself an interesting legal document. The first chapter of St. Paul's epistle to the Romans was given to a schoolboy as an exercise about 316 A. D., as may be seen in the fac-simile of the papyrus in our second volume of the Oxyrhynchus Papyri.

This epistle will appear in the next volume of our Græco-Roman branch under the title "Fayum Towns and Their Papyri." Messrs. Grenfell and Hunt are to go out again this winter to Egypt to seek for papyri at a new site. And now that the Harvard Semitic Museum is to be an accomplished fact, it is earnestly hoped by Dr. Lyon and others that a goodly number of valuable papyri from Egypt, through the generosity of friends, may be secured for its alcoves.—A letter of William C. Winslow, in the Boston Transcript.

THE HALL OF ILLUSIONS OF THE EXPOSITION OF 1900.

THE Hall of Illusions is, in a manner, the official "hit" of the Exposition, and, indeed, promptly gained the favor of the public. Such favor, in fact, was in all respects merited, not only by the richness of the decoration of the hall itself, but by the skillful arrangement through which a graduated series of impressions is experienced therein by the spectator. At first, there prevails a pitch darkness that leads to meditation and imposes silence upon the four hundred persons who are present at every seance. There is no impatience, and, while all eyes are trying to divine the motives of decoration in the obscurity, the sound of a small bell breaks the silence, and stars of a delicate blue suddenly illumine the hall with a soft glimmer. Then we see the columns, arches, festoons and chandeliers better, and we are seemingly in the center of an endless hall in which the galleries are bespangled with blue stars. But the color of the stars changes, and becomes at first red and then of a dazzling white. Then the arches light up in their turn, and finally the columns appear to be now of the purest white marble, and now of white marble tinted green or rose color. It is a true enchantment. We are seemingly living in a hall of cream, in a sort of temple, prodigiously vast and mysterious. To calm impressions succeed lively ones. Everything becomes of a dazzling whiteness—stars, arches, festoons, chandeliers and columns. Then, all at once, butterflies with wings of the most brilliant colors appear to descend from the ceiling and approach the spectators. And the exhibition (which must be seen to be appreciated, since a mere description can give no idea of it) thus comes to a close amid the frantic hand clapping of the crowd.

It is not rare to hear some one more curious than others ask: "How does all this operate, how is all this installed?" This, in fact, is not the least interesting side of the question, and we shall try to give an idea of it by indicating in the first place the principle of the work and the methods of working out its different parts.

The hall has the form of a regular hexagon inscribed within a circle of 36 feet radius, and the principle of the illusions resides entirely in the perfect (and it may be said wonderful) symmetry of the hexagon, and in the phenomena of multiple reflections of light from two parallel or angular mirrors.

For example, let us take the face numbered 1 in Fig. 2. This is parallel with face 4, and hence, for a luminous object placed between 1 and 4, in the center, *O*, of the hall, for example, results a "double infinity" of images that are regularly repeated in the mirrors 1 and 4. The same face 1 makes an angle of 60 deg.

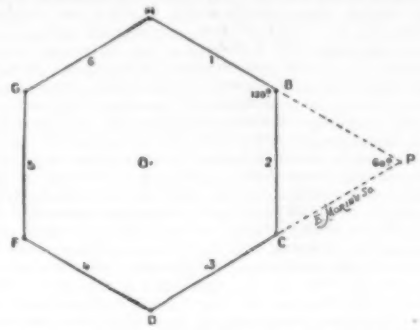


FIG. 2.—DIAGRAM SHOWING ARRANGEMENT OF MIRRORS.

with 3, and hence a double series of images distributed circularly over a circumference of a center, *P*.

There is a repetition of the same phenomenon for 1 and 5, which form the same angle of 60 degrees. There are analogous phenomena for 1 and 2 and 1 and 6, which form angles of 120 degrees. What we have said with regard to face 1 may be repeated for all the others. Hence results a circular repetition of the images ad infinitum, and, as may be seen, the principle of the exhibition under consideration is, upon the whole, that of the kaleidoscope. The effects obtained are wonderful. We think that they would have been odder still if the idea had occurred to give the luminous objects distributed throughout the hall diverse colors upon their different faces. In fact, to take the case of two parallel mirrors solely, we know that a blue and red ball, for example, gives in each a series of images alternately blue and red.

However this may be, the honor of having thought of the principle that we have just recalled belongs entirely to M. Henard, the architect of the Palace of Electricity. It was under his direction that all the studies were made, not only those relative to the architectural decoration properly so called, but also those relative to the installation. In this latter we shall distinguish two parts—the manufacture and mounting of the mirrors and the production of the luminous objects. The mirrors were liberally offered by the Saint Gobain works. It required twelve for each face of the hexagon, and each of them has a surface of about 129 square feet. If we consider how delicate is the work on mirrors that are to give repetitions of images, we shall not be surprised to learn that it required, on an average, the manufacture of four or five in order to obtain a perfect one. The cases that came from the manufactory were carried by cars directly under a trap formed in the flooring of the hall. From this, hoisted obliquely and then vertically by properly installed cranes, each mirror, fixed in its frame, was taken to the place that it was to occupy in the panel. All the regulating apparatus are fixed to walls of masonry, the use of which prevents those dilatations that would not have failed to occur with a purely metallic framework. The accompanying figures show the details of the suspension and regulating apparatus. The regulation constitutes the most delicate part of the installation. In fact, it is indispensable that every panel, consisting of connected mirrors, shall form as perfectly a plane surface as possible. Moreover, the regularity of the hexagon is obtained by making sure that the opposite faces are parallel. This double regulation is effected experimentally by examining the images formed by the mirrors and by maneuvering the screw apparatus that permit of inclining the mirrors in the two rectilinear directions until perfect regularity is obtained.

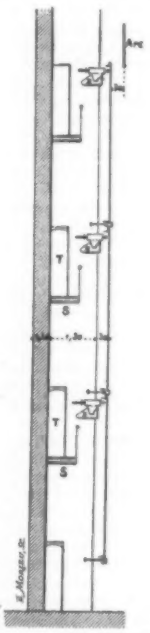


FIG. 3.—SYSTEM OF SUSPENSION OF THE MIRRORS.

T, doors formed in the masonry to give access to the galleries.

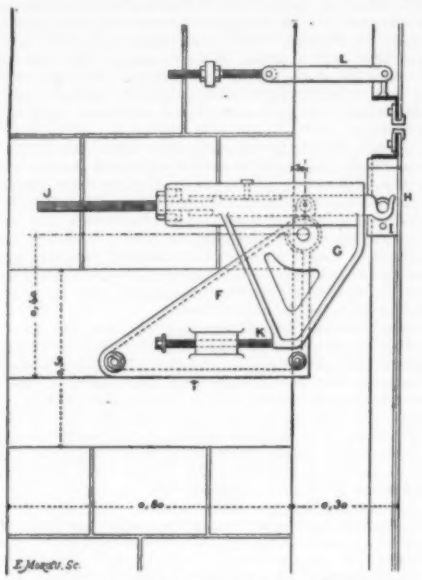


FIG. 4.—DETAILS OF THE SYSTEM OF SUSPENSION.

L, device to permit of moving the bottom of a mirror backward and forward; *H*, *I*, *J*, device to permit of moving the top of a mirror backward and forward; *K*, device to permit of bringing a mirror near the one that surmounts it.

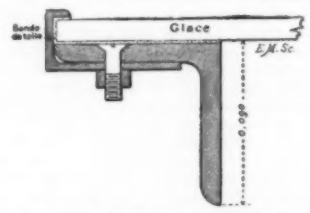


FIG. 5.—DETAILS OF THE FRAME.

If one of the mirrors happens to get broken, the system of suspension adopted will permit of pushing it forward 12 inches from the plane of the panel, in order to replace it without in any way altering the regulation of the rest of the panel. Each mirror, instead of being fixed with metallic clips, is imbedded in a soft substance, so as to prevent the breakage that would inevitably occur as a consequence of the unequal expansion of the glass and metal.

Finally, the variations in the lighting are controlled at a distance through the intermedium of interrupters devised especially for the purpose, and which are manipulated by means of a keyboard. It is thus possible to light festoons of lamps of different colors, or variously colored lamps in the interior of the hollow columns, etc. To this end, an innovation has been introduced into the projectors. The old system of colored glasses still employed in theaters never gives very pure colors, and, moreover, such glasses are quickly put out of service by the hot radiations of the electric arc. So they are here replaced by a current of colored liquid which circulates in a small glass tank placed in front of the lantern. It is possible to regulate the quantity of coloring matter in the liquid at will, and, independently of the variations in color, to obtain in this way variations in intensity of the most curious effect.

Such are, briefly stated, the principal points of the installation of the Hall of Illusions, in which, as may be seen, everything is scientifically arranged. This is

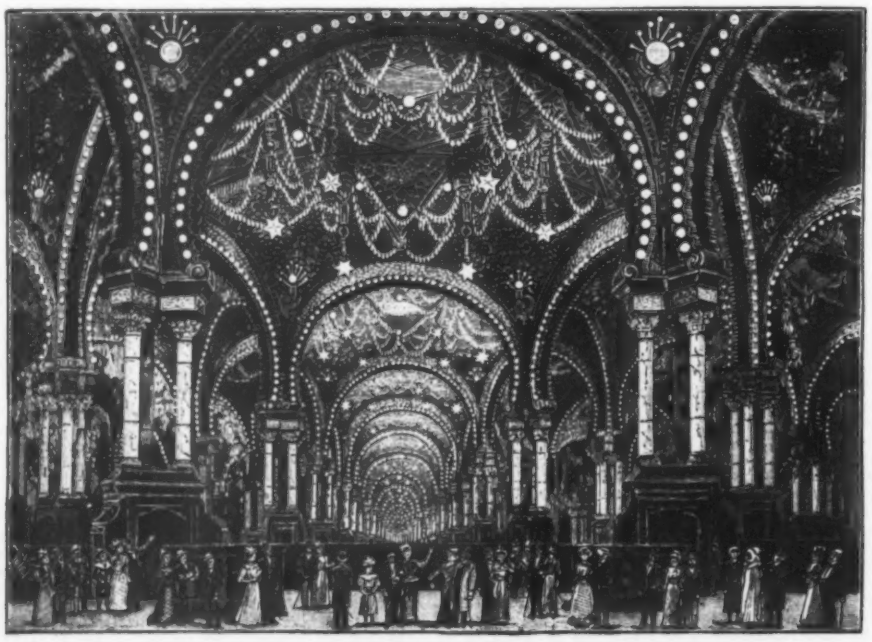


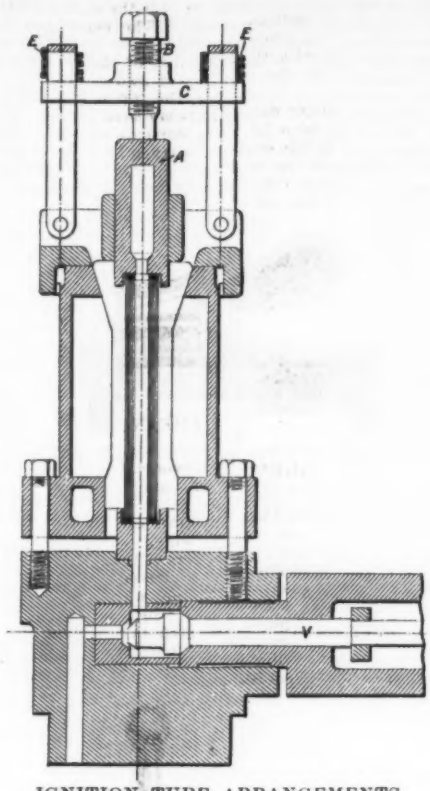
FIG. 1.—INTERIOR VIEW OF THE HALL OF ILLUSIONS.

a consideration that doubles the value of it, and fully justifies the enthusiasm of the crowd that continually seeks admission to the mysterious hall.—La Nature.

250 HORSE POWER GAS ENGINE.

AN exceptionally large gas engine recently completed by the Premier Gas Engine Company, Limited, Sandiacre, is the subject of the general view and longitudinal section given on this page. It has been designed for use with Mond producer-gas, and it has indicated 278 horse power with that gas, and over 300 with town gas. The diameter of the piston is 24 inches, and the stroke 30 inches. It is constructed on the positive scavenger system, well known in connection with this firm. A short explanation of the section drawing may be, nevertheless, acceptable.

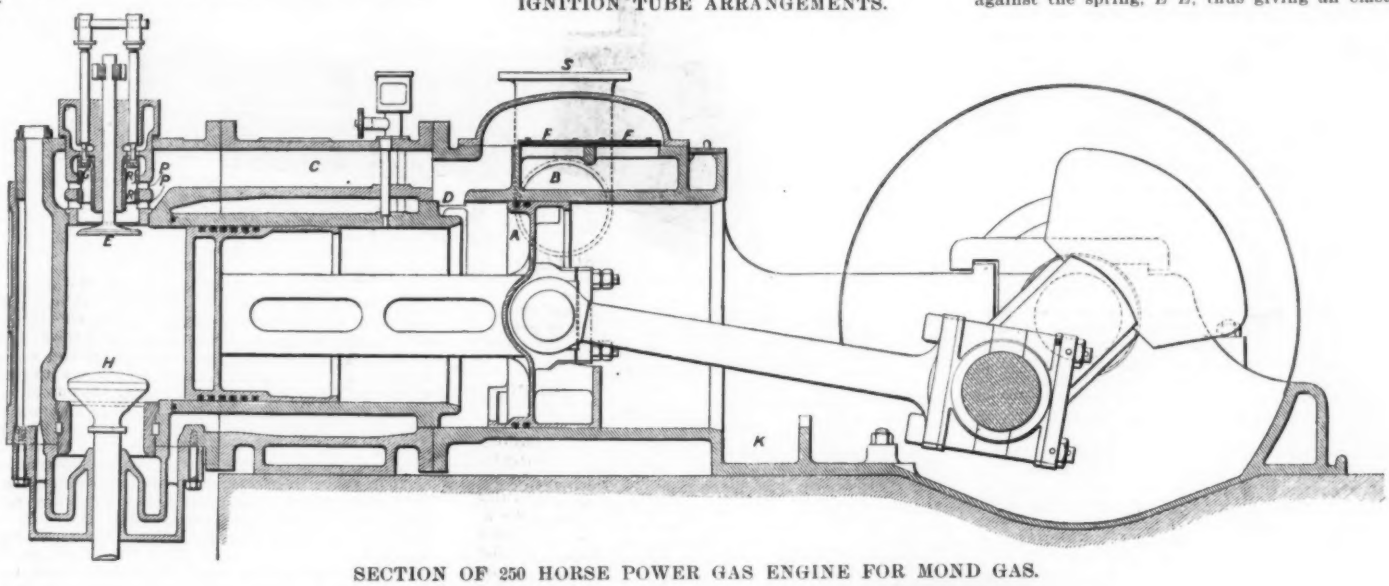
The large end, *A*, of the piston works in the cylindrical part of the bed-plate, thus acting as a guide and relieving the motor cylinder from the lateral pressure due to the obliquity of the connecting-rod. The gudgeon pin is shrunk into the connecting-rod, and works in the gun-metal bearings in the piston. The bottom of the piston has a shoe and the oil floods the lower side, being kept above the bottom of the cylinder by the oil well, *K*, in front of the latter. Air enters through the pipes, *S*, and port, *B*, and the light leather valves, *F*, a portion going along the passage, *C*, to the motor cylinder, and the remainder going through the port, *D*, to the pump space. On the return stroke, which is the compression stroke of the motor piston, the air is compressed into the clearance spaces, which are of such capacity that the pressure rises to about 5 pounds per square inch. On the next stroke, which is the explosion stroke, the air expands again to atmospheric pressure. On the next stroke, which is the exhaust stroke of the motor cylinder, the air is again compressed, but at about half stroke when the air pressure is in the neighborhood of 2 pounds per square inch above the atmosphere, the admission valve, *E*, is opened and the air rushes through the combustion chamber, the continued motion of the piston keeping up the discharge of air till the end of the stroke.



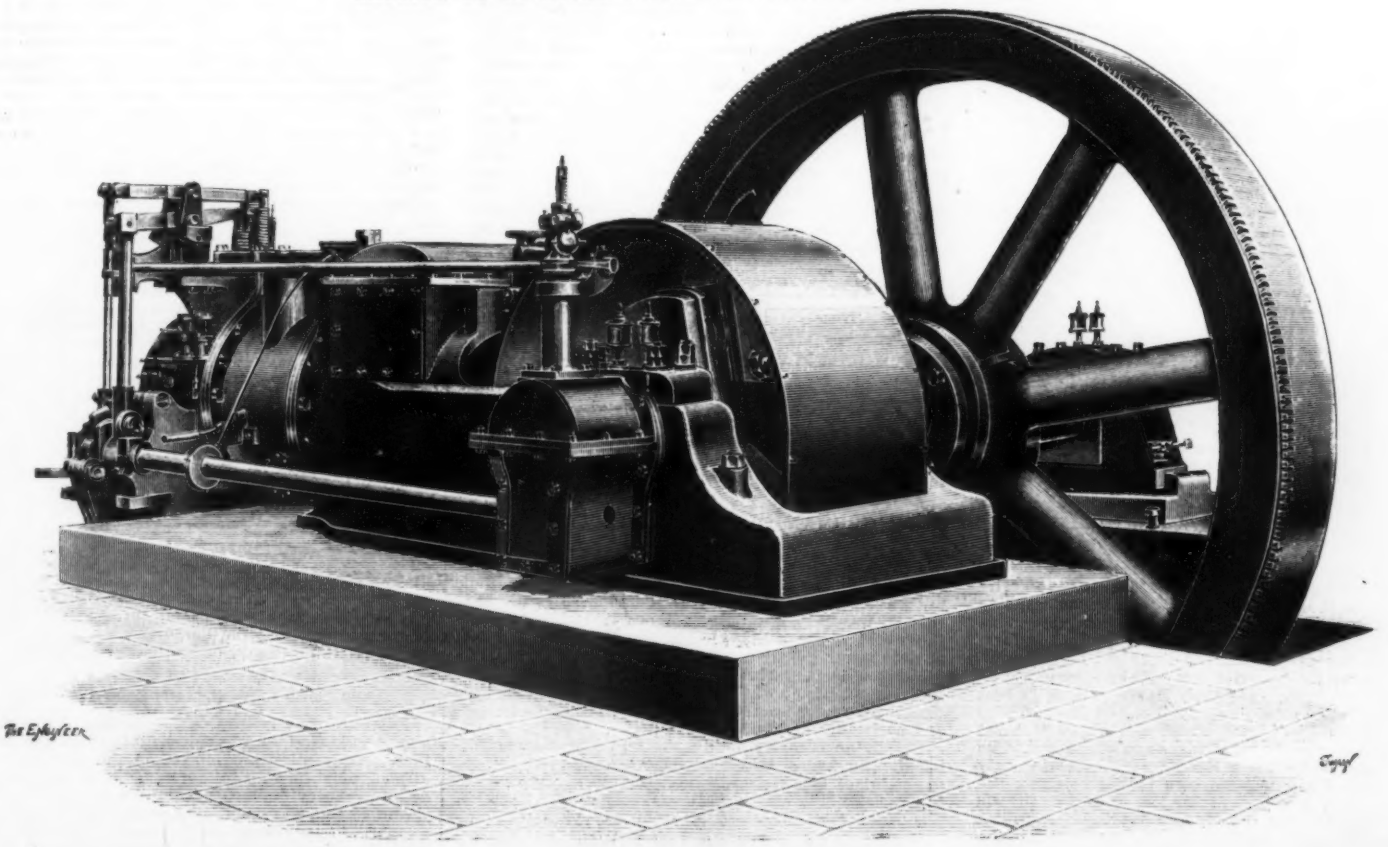
IGNITION TUBE ARRANGEMENTS.

The exhaust valve is closed early on the next out or suction stroke, and the gas valve, *G*, opened. This is an annular valve having rings, *R R*, attached to it, which rings partially block the air admission ports, *P P*. Thus, during the scavenging operation the air has a free passage through these ports, but during the taking in of a charge the air passage is sufficiently throttled to cause enough suction to draw in the proper amount of gas, which in the case of producer gas is a large proportion. When the governor cuts out ignitions the gas valve is not opened, and the air passage is free, thus allowing the engine to run with very little air resistance when lightly loaded. The piston and the exhaust valve, *H*, are water jacketed.

The advantages claimed for the scavenging arrangements are (1) Increase of power. (2) Reduced temperatures owing to the charge being cool before ignition. (3) Absence of premature explosions, or back firing, as there are no hot gases left in the cylinder to ignite the incoming charge. (4) Absence of explosions in the exhaust, because, first, the ignition is more certain and there is less risk of an explosive charge passing into the exhaust pipe; and, secondly, should a charge pass into the pipe the scavenging air comes between it and the next exhaust, thus preventing ignition of the explosive charge. (5) The engine does not get overheated and fall off in power after a few hours' run. If overloaded it slows down, but does not miss fire. (6) Good mechanical construction. (7) Clean working. (8) The valves being kept cool by the passage through them of scavenging air do not get burned or corroded, and very seldom require to be cleaned or ground to their seats. (9) The shocks are less than in ordinary engines, because the initial pressure is not so high and does not rise so rapidly, though the mean pressure is greater. The ignition is effected by porcelain tubes, admission to them being controlled by timing valves. These tubes and valves are in duplicate, so that should a tube burst it may be replaced without stopping the engine. The manner in which they are fitted is shown. The porcelain tube is held down by the piece, *A*, upon which the screw, *B*, presses. This screw works through a bridge-piece, *C*, which bears against the spring, *E E*, thus giving an elastic pres-



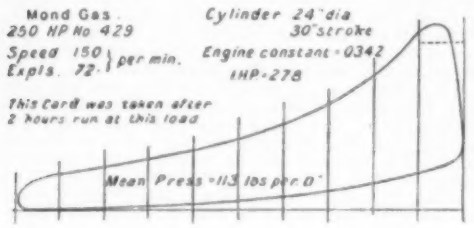
SECTION OF 250 HORSE POWER GAS ENGINE FOR MOND GAS.



250 HORSE POWER GAS ENGINE.

sure on the tube and allowing for free expansion, so that breakage of the tubes is very rare.

The governor controls the speed by cutting out ignitions and is driven from the crank shaft by level wheels with machine-cut teeth. The motion of the governor is conveyed to the push-piece by means of a torsion rod carried in ball bearings. The pins carrying the governor arms also work in ball bearings. The fly-wheel is 12 feet diameter, and weighs 14 tons, and the crank shaft is supported at the outer end by a massive plummer block having vertical and horizontal adjustments for the position of the brasses, so as to render alinement with the other bearings easy. The bearings are heavy gun-metal shells lined with anti-friction metal. Cast iron balance weights are fastened by means of straps to the crank cheeks. The engine is turned by hand by means of a barring gear, consisting of a pinion gearing into the teeth cast on the flywheel and operated by hand wheel. It is started by a self-starter, which consists of a pump for charging the cylinder with gas and air, which is ignited by opening one of the timing valves.


Mond Gas.
250 HP No 429
Speed 150 } per min.
Expls. 72 }
Cylinder 24" dia
30" stroke
Engine constant = 0342
IHP = 278
This Card was taken after
2 hours run at this load
Mean Press = 113 lbs per □"

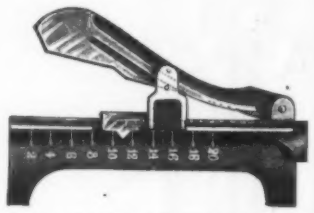
From the above indicator card it will be seen that the mean pressure is 113 pounds. The maximum pressure is only 310 pounds, so that, although the mean pressure is greater, the shock due to the explosion is less than in gas engines.—We are indebted to London Engineer for the engravings and particulars.

THE NEW RIFLE OF THE GERMAN ARMY.

THE 1888 model of the German army rifle, which was rather hastily adopted after the invention of smokeless powder, has proved defective in more than one respect, if L'Illustration is to be credited. The breech closing and the repeating mechanism leave much to be desired. Dust too easily enters the lower opening of the magazine; the bayonet is too short; the rear sight with its vertical leaf through which the line of sight passed by different notches is too complex; the walls of the rifle-bore are not strong enough; and the outer case or barrel cover is useless and even a source of injury. This outer case or barrel, the chief characteristic of German small-arms, is a tube of sheet metal which surrounds but does not touch the barrel, so that a small space is left which serves to permit the heated barrel to expand freely without being in any way checked by the stock. It was thought that by means of this construction the dispersion which results from a bending of the barrel would be reduced. In practice, the defects of the barrel-cover were soon apparent; for it was found the cover increased the weight of the weapon and actually prevented a rapid cooling of the overheated barrel.

It is claimed, the new gun which will be adopted is free from the defects mentioned. The weapon is of the same caliber as the old piece, so that like cartridges can be used; that, however, is the only essential point in which the two guns resemble each other. The barrel-cover is discarded; the walls of the barrel, much stronger than those of the old gun, are made up of a series of cylinders or truncated cones, from the muzzle to the breech.

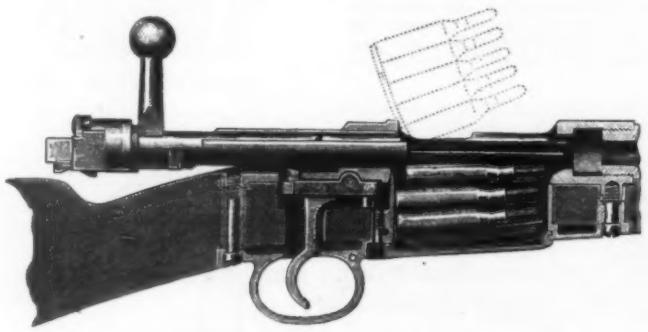
The rear sight, made after an entirely new design, comprises a sight bed or foot on which a slide moves, which is provided with an index and with two ears, the upper parts of which are each formed with two lugs in the same vertical line. The leaf of the rear sight, curved in form, is recessed on its upper face and is formed with two grooves on its sides. The two lugs or tenons of each ear of the slide move in the grooves to raise or lower the leaf. There is but a single sight notch, located at the free end of the leaf. The sides and base of the bed are graduated in hectometers.



SLIDING SIGHT OF THE NEW GUN.

should be remarked that the bayonet is fixed only to the forestock, so that its weight can in no way affect the barrel.

The new gun weighs 4 kilogrammes 100 grammes (without the bayonet, which weighs 430 grammes). Its extreme range is 4,000 meters. At 100 meters 80 centimeters of dry pine can be pierced; and at 1,800 meters 50 centimeters of dry pine can be penetrated. At 300 meters 7 millimeters of iron can be pierced. But at no distance has it been possible to penetrate 9.5 millimeters of good steel. The velocity of the projectile at 25 meters from the muzzle is 620 meters per second. The ballistic value of the gun is not greater than that of the model of 1888.



SECTION OF THE BREECH.

THE NEW GERMAN GUN AND ITS SWORD-BAYONET.

The magazine, similar to the magazines of all Mauser guns, consists of a sheet-metal case integrally formed with the trigger-guard, mounted adjacent to the breech casing, and wholly embedded in the wooden stock. Five cartridges are arranged in quincunx form (by which the depth required is reduced to a minimum) and rest on a carrier actuated by a spring. The uppermost cartridge constantly bears against one of the edges of the magazine opening, but is prevented from passing the edge by lateral springs which must be withdrawn when the cartridges are introduced. The cartridge can drop below the lip of the carrier only at the forward end, when driven by the bolt into the barrel-chamber. The Mannlicher loader used in the old gun is discarded for the Mauser loading-strip which holds the cartridges only by the bottom. To fill the magazine, the loading-strip with its cartridges is placed on the breech-casing, as shown by the dotted lines of one of our illustrations. By pressing upon the upper cartridge with the thumb, all the cartridges instantly slide into the magazine. The empty strip is then removed.

The 20-centimeter dagger-bayonet of the old weapon has given place to a 50-centimeter sword-bayonet provided with a flaring end. For the infantry and chasseurs the back of the bayonet is serrated to form saw-teeth. Prospective colonial expeditions have probably led the German war office to lengthen the bayonet. It

RECENT EXPERIMENTS IN MECHANICAL FLIGHT.*

IN the experiments of Gaston Tissandier, the balloon was made cigar-shaped, both ends being practically alike. The propelling force was a screw driven by an electrical engine. The machine was very carefully made, and was probably as beautiful a piece of workmanship as ever has been turned out. It was inflated with pure hydrogen. When it was tried, it rose in the air to perfection, and moved at a low velocity by means of its own screw and motive power, but the velocity through the air was considerably less than the velocity of the air itself, consequently it moved along with the wind very much like any other balloon. Other experiments were made, and it was found that the cigar-shape was not so favorable as a fish-shape balloon. Capt. Renard constructed several balloons, the greater part of which were fish-shaped; that is, full forward, and slim and tapering aft. In these balloons the very best accumulators and electrical engines were employed for propelling a screw of large diameter that was used. On one occasion, in a dead calm, the balloon ascended, traveled some three or four miles, and returned to the point of departure. It was drawn down and put back into the shed, where it had been built, and this is, I believe, the only instance in the history of the world where a balloon has returned to the point of departure.

Many other experiments have been made by Capt. Renard, who is, as is well known, employed by the French government, and who has unlimited means and assistance at his disposal.

But in no case, except in the one just mentioned, has he succeeded in making his balloons return to the point of departure. It was told to me by one of the assistants that the balloons only traveled about four miles an hour, and as the wind always blows a little more than four miles an hour, they were sure to travel with the wind exactly as all other balloons had done before.

In regard to the recent experiments of Count Zeppelin, it appears that a very large and expensive balloon was constructed. To prevent all the gas from getting into one end of its elongated form, as often happens, a considerable number of compartments were employed, each of which was filled with hydrogen gas. Instead of using an electrical engine, as had been employed in France, he used a much stronger and lighter motor, viz., a petroleum engine. The French, while acknowledging that a petroleum engine developed more power for its weight than could be obtained by electricity, appeared to be afraid to employ it on account of the great liability of igniting the gas in the balloon.

In the first accounts of these German experiments it was said that the balloon traveled 30 miles. We then hear that it traveled about three miles, and was finally towed back to the shed where it had been built. As all the information I have at hand is based on newspaper reports, and no two of these are alike, I do not feel that I have sufficient reliable data by me to draw any conclusions. I would, however, say that it appears to me quite useless to endeavor to make a balloon that would travel against the wind. A balloon, in the very nature of things, has to be lighter than the same volume of air. Its density is therefore very small. In order to be of sufficient size to lift itself, and any considerable load, it necessarily has to be of very great dimensions, and being of great dimensions, and as one might say, very soft and fragile, it cannot be made to travel against the wind. As before stated, balloons always have traveled with the wind, and it appears that this new German balloon is no exception to the rule. The experiments of Prof. Langley, Mr. Horatio Phillips and myself have been sufficiently successful to demonstrate that not only great lifting effect but also propelling effect may be obtained by the use of aeroplanes and screws; that is, with true flying machines—machines heavier than the air. But these experiments are extremely expensive, and require a great deal of time. Flying machines are sure to come in the immediate future. We certainly have enough skill in England to build one; I think the same may be said of the United States of America. In France, however, although they may have no more skill than we have, the abundance of money which they have at their disposal gives them a great advantage.

In regard to the use of flying machines there can be no question but what at first they will be rather risky things to play with. Their primary use will be for warfare. I think I may say that the danger of navigating such a machine, and of reconnoitering an enemy's position will not be greater than any other form of reconnoitering—in fact, I should say it would be infinitely less. I think flying machines would also be of great value for conveying dispatches over difficult country in time of war, to say nothing of occasionally dropping a bomb into the place where it would do the most good.

Flying machines, like automatic guns, make war more difficult and expensive. They will give to the highly civilized nation which has both money and engineering skill, great advantages over poorer and less skillful nations, which will, of course, be a potent factor in extending the borders of civilization, or, as one might almost say, of civilizing the world.

* A paper read by Mr. Hiram Maxim before the Aeronautical Society, July 17, 1900.

AN ALMOST ACCURATE CENSUS GUESS.

ACCORDING to The National Magazine, Edward Wigglesworth, "Hollis professor of divinity at Cambridge," in a little pamphlet published in the portentous year of 1775, must have had a correct idea of the prosperity of this country during the century just closing, as he predicted that the population of the "British-American colonies" in 1900 would be 80,000,000. Included in this estimate was Nova Scotia, now the Dominion of Can-

ada, which, with its last recorded census result of 4,800,000, added to the 76,000,000 of the United States, fulfills almost to the letter the accuracy of the Wigglesworth prophecy. This remarkable forecast was not based upon any species of guesswork, but upon a well-defined and clearly constructed mathematical theory, which, reduced to plain words, can be best described in the language of its author. "The British-Americans have doubled their numbers in every period of twenty-five years from their first plantation." Taking this statistical fact as a basis for his calculations, the Harvard professor constructed a system of reckoning the increase of a country's population, which history has shown to be as correct as his method was simple. Assuming that the 1775 population was 2,500,000, Professor Wigglesworth estimated 5,000,000 for 1800, 10,000,000 for 1825, 20,000,000 for 1850, 40,000,000 for 1875 and 80,000,000 for 1900; and the record of the United States census, since its initial taking in 1790, shows substantially these figures, as follows: Census of 1800, 5,308,000; 1825 (1820), 9,633,000; 1850, 23,191,000; 1875 (1870), 38,658,000; 1900, with Canada, 81,000,000.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Rafia Fiber in Madagascar.—Rofia, or as it is generally spelled in commerce "raffia" or "rafia," is the Malagasy name of a palm which furnishes a staple article of commerce called rafia fiber. It is indigenous to Madagascar, and is to be met with everywhere on the coasts, needing no cultivation or attention of any kind. It is not a stately palm, but sends it enormous branches from near the ground; in a fine specimen, one branch is almost a tree in itself. The rib of each branch is as much as 20 feet long, of a pearly gray color, smooth and shiny, flat on the inner surface, but otherwise round, without any knots, and so hard that in perhaps nine cases out of ten a rifle ball would rebound therefrom. At the base it is as large as an ordinary champagne bottle and tapers to a point at the top. The inside consists of a light pith, which can be split into layers of any thickness. Possibly it is this or an analogous production which is used for making pith helmets in the East.

Naturally, these ribs combine great strength with wonderful lightness, and are used for shafts for "filanjanas," or palanquins, ladders, and other purposes, but otherwise have no particular commercial value.

It is the pinnifoliate of these branches which produce the rafia fiber of commerce. One palm branch, or frond, will produce eighty or one hundred long green leaves from two to five feet in length, like the leaves of the sugar cane, but of a dark, lustrous green and thicker and stiffer. These, again, contain a round and pliant rib, which the natives utilize for making baskets and dredges for catching small fish and shrimps in the rivers after they have stripped off the green part which furnishes the fiber.

The under part of this green leaf (which is not exposed to the light, as it remains folded) is of a pale greenish-yellow color, and from that side the inner skin can be peeled off in the same manner as the skin on the outside of a pea pod, except that it peels off straight to the tip without breaking. It is then of the palest green, and after being dried in the sun assumes a light straw color. This is the rafia fiber of commerce.

It was originally exploited by the natives for use in articles of clothing. The men bring in the fronds and women and girls weave it on handlooms of any coarseness or fineness. Woven just as it is peeled off from the fronds it forms a kind of sacking used for wrapping goods, while the perfection of the art, as known by the Hovas only, is to weave a tissue of which the warp is rafia fiber split infinitesimally fine, and the weft of white silk. This gives an article called silk lamba, which brings fancy prices in Europe and America. The coast tribes use it for clothing, but of mediocre fineness, with dyed stripes of indigo, saffron, black, and a dirty green. It is a cold, comfortless-looking material, and refuses to adapt itself to any folds that a sculptor would care to copy; and when two natives come down the street clad in brand new rafia shirts they produce a noise similar to that of two wire meat covers rubbing together.

Rafia fiber is now used in the market, I understand, entirely by nurserymen, gardeners, etc., for tying up vines and flowers, and possibly for grafting. It possesses the advantages of being as soft as silk and is not affected by moisture or change of temperature so as to risk cutting or wounding the most delicate tendrils; and it does not break or ravel when folded or knotted. These qualities bring it into use all over Europe, and consequently maintain its price. It is virtually inexhaustible in Madagascar, the supply being limited only by the scarcity of labor.

For export the fiber is merely collected in large skeins, twisted up or plaited, and then baled like raw cotton.

Madagascar exports about 20,000 bales annually, and the present prices range from 78 to 80 francs ($15.05 to $15.44) per bale f. o. b. New York.—William H. Hunt, Vice-Consul at Tamatave.

Rubber in Guatemala.—Frequent inquiries are received at this consulate concerning rubber, its cultivation and the manner of its treatment, says Consul-General James C. McNally. Many attempts have been made to manufacture a substitute for this valuable substance, but up to the present time nothing has been found to even partially serve in its stead.

To one contemplating the cultivation of rubber, the primary consideration is to locate suitable land. Some lands, while having all the elements required for fruitful production, lack the fertility necessary for quick growth. The time required for development depends entirely upon the soil and the advantages of location. Some lands will develop the growth of the tree so rapidly that in seven years it will produce milk, while others need from nine to ten years. Land located near the sea and at its level, having the full benefit of the sea breezes, will produce in much shorter time than land of a higher elevation and farther inland. In the cultivation of rubber one must also cultivate patience, for at least seven years are required before any return is made on the investment; however, cocoa, sugar cane, tobacco and other marketable products can be raised at the same time, which will pay expenses for rubber cultivation.

The rubber tree is what is commonly called croton germ, and when any part of it is planted in soil favorable to rubber, it grows more rapidly than when seed is planted. In this case, it must be transplanted to the place set apart for its final development.

In Guatemala and all Central America, the Castilloa elastica is cultivated, and its product is of fine quality. The Castilloa elastica is a tall and well-shaped tree, having a smooth bark of a whitish-green color; it attains to a height of forty-five to sixty feet. The branches—few in number—grow very long and almost horizontal, and out of them spring two rows of long oval leaves.

The product or milk of this tree exists in the fibers located between the bark and the tree. These fibers are the vital part of the tree, which fact necessitates the greatest care in making incisions to extract the milk. Should one accidentally cut into these fibers, the life of the tree would be endangered. It is estimated by good authority that the milk of the rubber tree contains about 60 per cent of water and other substances and about 40 per cent of rubber; and, allowing for further losses in its treatment, one can count on 33 1-3 per cent of the whole being rubber of good quality.

Only of recent years has rubber cultivation been seriously thought of. Before this time milk was taken from trees growing wild, and one spoke of "hunting" rubber.

The rubber tree must not be exposed to the extreme rays of the sun, and should, therefore, be shaded by other trees; but not so much as to prevent the free passage of air, for ventilation is essential to the growing plant.

Some planters insist that rubber and coffee will grow on the same land, and therefore plant the rubber tree to serve as a shade for coffee and cocoa. While the coffee and cocoa would undoubtedly be benefited by the shade of the rubber tree, the product of the latter would be of little value, as the sun would sap the vitality of the tree. Rubber trees at high elevations, though beautiful in growth, give but little milk. Not all trees produce milk even at a favorable altitude. The tree called the female yields the product; the male tree gives nothing. It is necessary, however, to plant the male species, for experience has demonstrated that a plantation of female trees alone would be fruitless and unproductive. Successful rubber planters from whom I get my information say that among every thirty-five female trees there should be one or two male trees. The male tree, when the incision is made, gives out a puff of wind, but produces no liquid.

The soil where the rubber is planted should be loose and deep, with no clay or stones. The land should be clean for at least three feet around the tree. The ground must be well worked before the rubber seed is planted; the soil must be damp, and the seed must be placed about two feet apart. The seed should be picked in March, as it falls from the tree with the gum on it. If washed, it may destroy the seed. In about a year, the little plant will be one and one-half feet high. It must be stripped with the greatest care and the roots covered with dirt; it should then be transplanted. For the first year, the plant should be kept free from weeds or it will become choked. The transplanting method has always proven more efficacious than planting the seed; this also enables one to select the healthier plants and guarantee production. The rubber trees should be about six yards apart, and, if the shade trees will permit, should be placed in rows. Weeding about the tree must be done at least four times a year during its early growth; this care lessens as the tree matures. Weeding is done with a machete. The weeds and some branches of neighboring trees are cut into small particles and strewn around the tree to act as a fertilizer.

Opinions differ about the time required for the mature development of the rubber tree, but, as before stated, much depends on the location and soil, as well as on the care given the growing plant. Some planters say that the rubber tree when fully developed will yield from 3 to 4 pounds of milk yearly, while others think this estimate too liberal. The life of a rubber tree is impossible to estimate; trees growing wild in the forests here seem to be hundreds of years old, and still give milk as frequently as those of later cultivation, though not in such quantities. The tree can be bled twice a year with safety; more frequent tapping will injure it.

After the tree has developed, very little care is required other than to keep down the weeds, etc. The wild trees above mentioned each yield about 2 pounds of rubber yearly, without the least care other than what nature has given, showing that attention is alone necessary to increase the production and improve the quality. The tree should be bled at certain prescribed seasons; the best is when the leaves have fallen off and the tree is nearly stripped. The yield at this time is greater than at any other. The incision in the tree is made in the form of an S. One incision at the bottom of the tree is not enough, because the fibers are not good conductors, and the milk thickens by exposure and prevents free flowing. In making the incision care must be taken not to cut the fiber, as above mentioned; the incision must extend through the bark only.

As to the treatment of the milk when extracted opinions differ. The natives make a canal in the tree and let the milk run into a hole in the ground made particularly for that purpose, which answers as a receptacle. In the process of hardening or solidifying dirt is taken in, and, of course, the rubber is not pure and is of less value. Some permit the milk to flow into a barrel, and the juice of a vine, "quiebra-cajite," is used to solidify. Alum, which has an almost immediate effect on the rubber, is much used. An indirect fire is also used to cause the evaporation of the water in the milk. Care should be taken to prevent the receptacle or vessel used from staining the rubber. Another process is to pour the milk into water; the milk hardens immediately and when taken out is in appearance much like a sponge. It should then be passed through a press and all the water squeezed out; an American wringer can be used for the purpose. When this is done, the rubber is of a whitish color and is the pure product.

Every inquiry received desires data as to the probable cost of rubber production. This is difficult to give, as much depends on the person engaged in the work. However, these points must be considered: The cost of the land, its location, and the quality of the soil; the facility for securing workmen; the means for getting the rubber to the coast or railway, etc. It is estimated that 100,000 trees can be planted in one caballerie (about 115 acres), which land can be purchased for about $100 an acre. The labor is cheap; the native workman getting about 6 reales, or 12 cents in United States currency, a day. Small, inexpensive huts must be erected on the plantation for the workmen. Plantains are the food used, and these can be grown in sufficient quantities without any expense whatever. After the trees are planted, very little cost is incurred, unless the planter is raising other marketable products. I know of no enterprise or business requiring as little money as the cultivation of rubber. After the seventh year each tree can be counted upon to give a product worth at least $1 gold per year, and sometimes $2. When the tree begins to yield it must be protected from rubber thieves, who not only steal the rubber, but slash and cut the tree so badly that it dies. Sugar cane, coffee, etc., can be grown at the same time, which will not only pay the expenses of the finca, but will yield good returns. Thus the cost of the cultivation of rubber is minimized. Part of the plantation can be reserved for the raising of cattle, which is very remunerative in Guatemala. The pasture land is of the best, and if water is near by the ranch can be established without further outlay.

The rubber lands in Guatemala are equal to any in the world, and with proper care and intelligent cultivation the product will command a price equal to any. There are two seasons here, commonly called winter and summer. The summer season extends from October 15 until about May 1, and is the dry period. The winter, or rainy, season lasts from May to October. The climate, soil, and atmosphere of Guatemala are entirely favorable to the cultivation, not only of rubber, cocoa, tobacco, coffee, and sugar, but of all vegetables and articles of domestic use. It is, in my judgment, the ideal land for the farmer, who, with the application of modern farm implements, could win a recompense for his labor much beyond that to be obtained in our own country. Two crops a year can be raised, and there is absolutely no limit to the articles of farm production which could be cultivated here.

Pianos in Brazil.—Under date of December 3, 1900, Vice-Consul-General Hanauer, of Frankfort, sends the following:

The Austro-Hungarian Consul-General at Rio de Janeiro, in a report to his government, calls the attention of his countrymen to the favorable chances for selling pianos in Brazil. He says:

"French pianos are well introduced here, but these instruments have of late deteriorated in their quality. After two or three years' use their sound becomes unbearably metallic. Nor is sufficient regard paid to the hot and moist climate. Still, for want of better instruments, and because the French article has been well advertised, they continue to meet with ready sale at high prices. Last year, a few pianos of Bohemian (Austrian) manufacture were introduced in Curityba, the capital of the State of Parana, and have given great satisfaction. One of the best-selling pianos is the short square, called 'Mignon,' 175 centimeters long, 7¼ octave, which sold at the factory for 400 Austrian florins (about $160 in United States currency). Pianos which are more popular and most in use cost at the factory about 300 florins ($120).

"These instruments must be ornamentally and highly finished, have cast-steel frames and light mechanism, which, however, must be impervious to moisture."

South American Steamship Service.—Consul-General McNally sends from Guatemala, November 30, 1900, an advertisement, with translation, announcing the extension of the Pacific Navigation and the South American Steamship companies' lines to San Francisco. The translation reads:

THE PACIFIC STEAM NAVIGATION COMPANY AND SOUTH AMERICAN STEAMSHIP COMPANY.

The above-mentioned companies will begin a fifteen days' service between South and Central America, Mexico and San Francisco, stopping at the principal ports, carrying passengers and cargo at low prices. The first steamer will leave Valparaiso the 26th of December next and San Jose probably the 20th of January, 1901. For more details apply to F. W. Melville, special agent for central America and Mexico.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

No. 940. January 21.—Proposed Railroads in British Columbia—Guatemalan Railway Contract—German Prize for Benzine Substitute.

No. 941. January 22.—New Steamers for the West India Fruit Trade—The World's Grain Production—Cable to Australia—*English Trade Unions.

No. 942. January 23.—The Trans-Siberian Railway—Indebtedness of Nicaragua—Reduction of Copper Ore in Peru—Competition of Electric Vehicles in Berlin—Railroads of Roumania—Demand for Motors in Madagascar.

No. 943. January 24.—Panic in German Paper Trade—Argentine Trade in 1900—Transportation in the Kongo—South American Steamship Service—Wheat Crop of Argentina and Uruguay.

No. 944. January 25.—*American Furniture in Germany—*Maltese Trade Information—The Mosel-Saar Canal of Germany—Coal Trade of Hungary—Cod-Liver Oil in Venezuela—New Cruiser for British Columbia coast.

No. 945. January 26.—Fishing Industry of Eastern Siberia—Acetylene Gas vs. Petroleum in Germany.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

TRADE NOTES AND RECEIPTS.

Bronzing by Means of Soluble Glass.—To bronze wood, porcelain, glass and metal by means of a water-glass solution, coat the article with potash water glass of 30 deg. Bé. and sprinkle the respective bronze powder on.—Werkstatt.

Creme de Noisette.—Make a paste of 15 grammes of starch, 15 grammes of quince seed and 1 kilo of water. Strain it through muslin, dissolve 4 grammes of boracic acid in 360 grammes of glycerin and mix the latter solution with the compound. To this mixture add slowly, and with vigorous shaking, 360 grammes of spirit, which may be scented ad libitum, and make up 2 kilos by addition of water. The finished preparation is colored with persicot tincture and filled in bottles.—Pharmaceutische Post.

Coating for Heating Pipes.—The pipes are cleaned, washed off with hydrochloric acid solution and rinsed well with lime water; next they are painted with linseed oil varnish, to which a little red lead varnish is added, and dried. In place of the red lead varnish, graphite may also be employed. On this varnish layer apply, several times, a mixture of chalk and linseed oil varnish, to which a little zinc dust should be added. The mixture must be used as thick as possible, but the previous coat must always be perfectly dry before the succeeding one is put on.—Der Bierbrauer.

To Protect Iron Against Atmospherical Actions.—The surface of the iron is freed from all adhering impurities and treated with a current of superheated steam of about 600 deg. C. A coating of magnetic ferric oxide will form, which protects the iron from all exterior actions and adheres very firmly. This coating shows a color of dark dull steel gray. If it is desired to increase the action of the steam, a little naphthaline is placed in the steam generator, and also allowed to evaporate. The gaseous hydro-carbons contribute to increase the thickness of the coating, which is thus rendered more adhesive.—Der Bierbrauer.

Artificial Raspberry Juice.—Artificial raspberry juice, a product which is in demand now and then, is prepared in the following manner:

Heat for one hour in the vapor bath citric acid 5 and sugar sirup 7.75 in a covered porcelain dish, replace the evaporated water and add at once purified pale yellow honey 200, and raspberry essence 20; color with cochineal or inspissated juice of red beets.

According to Holfert, artificial raspberry juice is produced as follows: Citric acid 40 grammes and saponin 3 grammes; dissolve in 120 grammes of water, raspberry water 75 grammes, raspberry red (Helfenberg) 75 grammes, liquid refined sugar 10 kilos.—Pharmaceutische Zeitung.

Chemical Action of Petroleum, Rapeseed Oil, etc., on Various Metals.—In the Zeitschrift für Analytische Chemie, Gawalowsky gives an account of his exhaustive analyses regarding the chemical action of petroleum, rapeseed oil, as well as acetic acid on technically important metals and their alloys. He has determined that for crude petroleum, copper, nickel, aluminium, tin and iron are excellently adapted for pipe conduits, manufacturing and storage receptacles, while zinc and lead are less suitable. For purified petroleum, however, lead, copper, iron and brass, even nickel, tin and argentan are commendable. Aluminium and zinc are less eligible; altogether unsuitable is copper phosphide (phosphor bronze).

For rapeseed oil mills, lead, iron, nickel, and aluminium are advisable, while zinc, tin, brass, argentan, and especially copper-bronze and phosphor-bronze must be excluded.

Plants of the fermentation industries may use tin, brass, phosphor-bronze, also lead, nickel and argentan, but no iron, aluminium, and above all, no zinc. Acetic acid factories should use only nickel, aluminium and tin.

Decomposition of Cement by the Action of Bacteria.—(From the German of Prof. A. Stutzer, and R. Hartleb, M. D., in the Zeitschrift für Angewandte Chemie.) We have had occasion to examine a cement taken from reservoirs, where it had remained in contact with water for eight or nine years. The cement had grown poorer and poorer in lime, and was converted into a soft brownish mass, while its proportion of ferric oxide, alumina, etc., had increased. We concluded that the changes were due to the fact that the carbonic acid of the water had gradually dissolved the lime, with formation of calcic bicarbonate, and are still of that opinion. But there appears to have been a co-operating cause, in the action of bacteria on the lime.

Some of the mass was rinsed several times in sterilized water, and small quantities were placed in a liquor containing one gramme of ammonium sulphate and one gramme of sodic nitrite per liter.

At the end of six days the solution was examined and then contained nitrite. At the end of eleven days the reaction of nitrous acid was very strong and the action of ammonia weak. The ammonia had evidently been converted into nitrous acid by the action of bacteria, and this was able to dissolve a part of the lime.

The solution containing no nitrogenized matter, it was after a long time that the nitrite had been completely converted into nitrate under the influence of the cement. It is extremely probable that, with reference to the dissolution of the cement, the formation of nitrite is more important than that of nitrate. It is the presence of an acid body, nitrous acid, that determines, at the same time as the carbonic anhydride, a dissolving action on the cement.

Our microscopic examination has revealed in every case the presence of numerous hypo-microbia, whose characteristic forms are easy of recognition, and which are developed in abundance in fourteen days in solutions containing nitrite, nitrate or asparagine.

Sea water will also gradually exercise a destructive action on cement, unless it contains a proportion of silica. As carbonic acid cannot intervene as a dissolving agent to the same extent as in fresh water, it may be supposed that the dissolved sulphates react little by little on the lime. We have not yet had the opportunity to examine whether sea water also contains micro-organisms, able to exercise on the lime a dissolving action.

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